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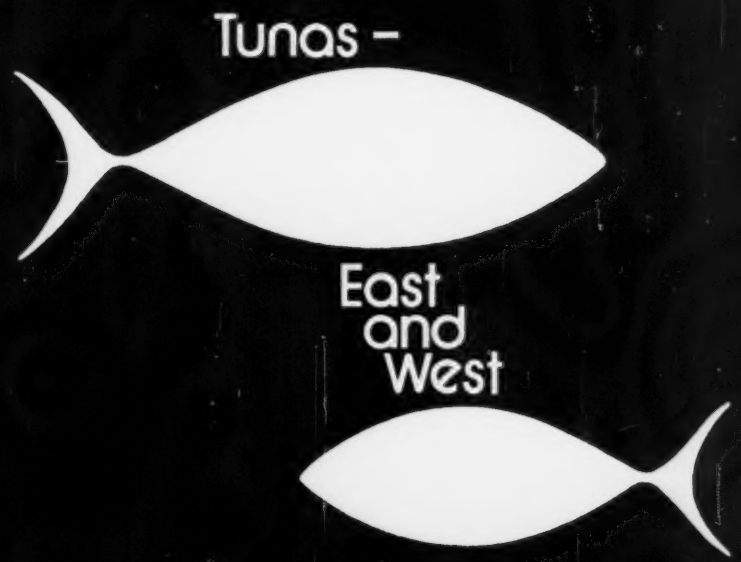

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MFR PAPER 1126

The Purse-Seine Fishery for Bluefin Tuna in the Northwestern Atlantic Ocean

GARY T. SAKAGAWA

Purse seining by commercial fishermen and trolling by recreational fishermen for bluefin tuna off the east coast of the United States. U.S. commercial and recreational fishermen compete for bluefin tuna during the summer and fall months offshore from New Jersey to Maine.

ABSTRACT—The history of the purse-seine fishery for bluefin tuna in the northwestern Atlantic Ocean is reviewed, and events that contributed to fluctuation of the catch are discussed. The fishery began in 1958 and produced 5,770 mt (metric tons) at its peak in 1963. The catch declined from 4,290 mt in 1970 to about 1,780 mt in 1973. The 1973 catch was landed by a fleet with about 4,900 mt carrying capacity, which was in excess of the catch. Average length of bluefin tuna in the purse-seine catch decreased from about 140 cm in 1960 to about 89 cm in 1973, owing in part to a southward expansion of the fishing grounds into areas where small bluefin tuna are more available. Prior to 1962, the fishing grounds were centered in Cape Cod Bay. Currently it is centered off New Jersey-New York. The nominal catch rate of Class 3 seiners has fluctuated, but it appears that the prevailing trend in the 1970's is downward with the current rate at a low level.

INTRODUCTION

The northern bluefin tuna (*Thunnus thynnus thynnus*) was considered a nuisance by U.S. fishermen of the Atlantic coast until at about the turn of this century a domestic market was developed, first for the oil then only for the meat (Bigelow and Schroeder, 1953). Traps, harpoons, and handlines were the primary gear used to catch bluefin tuna in the northwestern Atlantic before 1958. The total Canada-U.S. catch averaged about 900 tons[1] annually in 1942-57. In 1958, purse-seine fishing was introduced (Squire, 1959; Wilson, 1965), and the total catch (all gear) increased to an average of 2,800 tons annually (Fig. 1), but the catch has fluctuated considerably. In fact, the total catch since 1969 declined from 4,800 tons in 1970 to 2,400 tons in 1972. This report reviews the development of the purse-seine fishery for bluefin tuna in the northwestern Atlantic and describes some events that had a bearing on fluctuation of the catch.

THE FISHERY

Canada and the United States are the only participants in the purse-seine fishery for bluefin tuna in the northwestern Atlantic Ocean. As early as 1937 purse seines were experimentally used to catch bluefin tuna in the northwestern Atlantic (Murray, 1952). However, the fishery, as we know it today, essentially began in 1958 when the *Silver Mink*, a 41-ton carrying capacity U.S. purse seiner, demonstrated in Cape Cod Bay, Mass. that bluefin tuna could be caught commercially (Squire, 1959; Wilson, 1965). From 1958 to about 1962 only small, U.S. seiners (<92 tons carrying capacity), based in New England ports, participated in the fishery, which was centered in Cape Cod Bay. In 1962, the fishery expanded southward as far as North Carolina (Wilson, 1965). In 1963, Canadian seiners (100 tons capacity) and large, California- and Puerto Rico-based seiners (>363 tons capacity) entered the fishery. These

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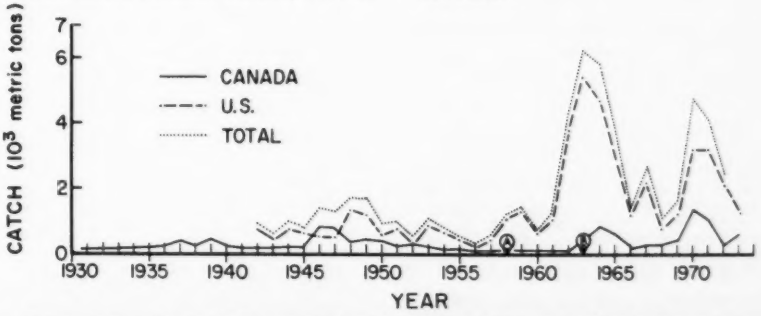


Figure 1.—Canadian and U.S. commercial catch of bluefin tuna from the Atlantic Ocean: A, the year 1958 when the purse-seine fishery first started; B, the year 1963 when large seiners (>181 tons capacity) first entered the fishery. The 1973 catches are preliminary and only includes purse-seine catches.

[1]Tons refer to metric tons in this report.

events transformed the fishery into one with cosmopolitan participation with vessels fishing for bluefin tuna as well as the tropical tunas, yellowfin (*T. albacares*) and skipjack (*Katsuwonus pelamis*), that occur in fishable quantities in some years off the east coast of the United States (Wilson, 1965).

Unlike the trap, harpoon, and handline fisheries that generally catch large bluefin tuna (>122 cm long[2]), the purse-seine fishery primarily catches schooled bluefin tuna, 50-122 cm long, which are sold to canneries for processing into canned tuna. Fish larger than about 140 cm long are generally undesirable for canning and are sold to fresh-fish markets. (Currently, Japan is an important market for the large fish.) In any one year, not more than about 16 percent of the purse-seine catch, in weight, has been large bluefin tuna.

The purse-seine fishery operates within a narrow belt that extends about 220 km from the coast. Fishermen claim that not many schools are found beyond that region. Mather and Schuck[3] indicated that schooled bluefin tuna are found in the northwestern Atlantic between Cape Charles, Va. and Newfoundland, but primarily between Cape Charles and Cape Cod, Mass.

Through the years the use of land-based aircraft to assist seine fishermen in locating and setting on schools of bluefin tuna has become popular. Virtually all the small seiners and some large seiners currently use aircraft in fishing operations. The technique is quite effective in that it increases the searching range and fishing success of the vessels. This is probably a major factor contributing to the ability of the small vessels to consistently catch a large share of bluefin tuna from the northwestern Atlantic (Sakagawa and Coan[4]).

[2]Length measurements are straight line distances from tip of snout to fork of tail.

[3]Mather, F. J. III, and H. A. Schuck. Contribution to the biology of the bluefin tuna (*Thunnus thynnus*) of the western North Atlantic. Part I. Age and growth, distribution, and migrations. Manuscript, 177 p. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543.

[4]Sakagawa, G. T., and A. L. Coan. A review of some aspects of the bluefin tuna (*Thynnus thynnus thynnus*) fisheries of the Atlantic Ocean. Manuscript, 83 p. National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California 92037.

TOTAL CATCH

The total Canadian-U.S. landings (all gear) of bluefin tuna from the northwest Atlantic historically fluctuated around 900 tons annually until 3 years after the purse-seine fishery became established in 1958 (Fig. 1). The total landings then increased sharply from 1,200 tons in 1961 to

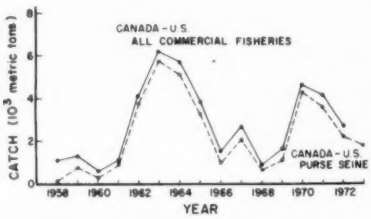


Figure 2.—Total Canada-U.S. commercial catch of Atlantic bluefin tuna by the purse-seine fishery.

Figure 3.—Percent distribution of catch of bluefin tuna and fishing effort for purse seiners participating in the bluefin tuna fishery of the northwestern Atlantic.

Table 1.—Purse-seine catches (Canadian and U.S. combined) of bluefin and skipjack tuna in the northwestern Atlantic Ocean, 1958-73.

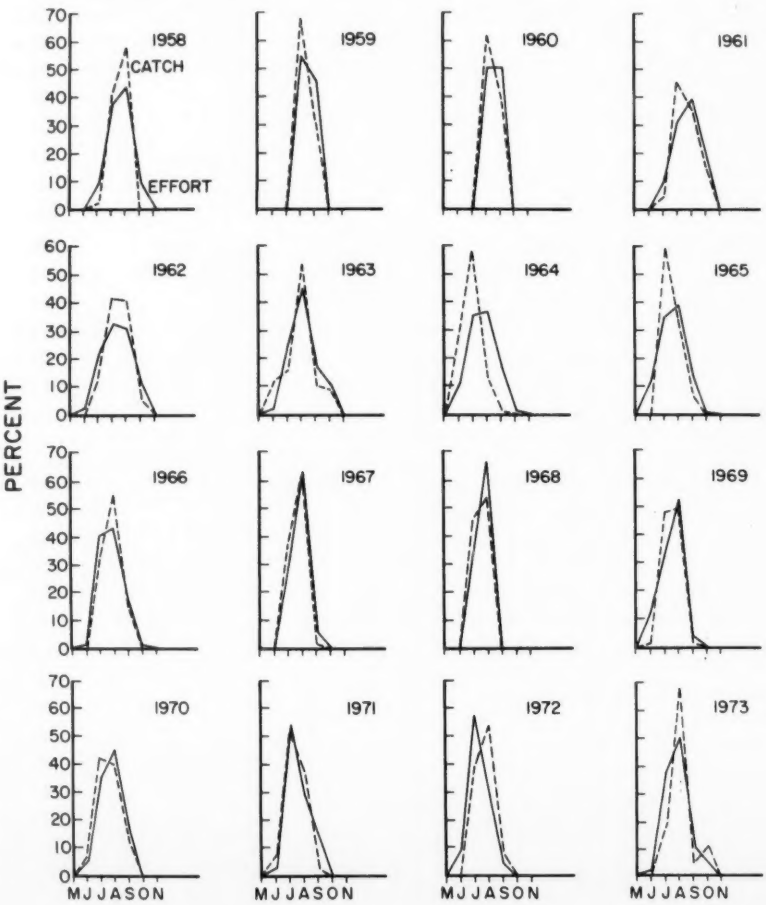
Year	Number of seiners	Catch (metric tons) Bluefin[1]	Skipjack[2]	Total
1958	1	138	0	138
1959	1	781	0	781
1960	1	277	0	277
1961	2	903	0	903
1962	7	3,767	434	4,201
1963	18	5,770	2,899	8,669
1964	21	5,167	4,974	10,141
1965	13	3,331	179[3]	3,510
1966	7	1,006	149[3]	1,155
1967	11	2,083	3	2,086
1968	5	688	2[3]	690
1969	4	1,118	103[3]	1,221
1970	8	4,287	650[3]	4,937
1971	12	3,825	610[3]	4,435
1972	11	2,137	44[3]	2,181
1973	7	1,781[4]	35[4]	1,816[4]

[1]Sources: Aloncle et al (1972), Fishery Statistics of the United States (1960-69, 1971-73) and Statistics and Market News Division, National Marine Fisheries Service, Washington, DC 20235. Virtually all bluefin tuna are landed in the year caught, and landings are considered catches in this report.

[2]Estimated catch statistics from Mather, F. J. III, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 (pers. commun.) except those from logbooks (see footnote 3).

[3]Estimates from logbooks.

[4]Preliminary estimates.



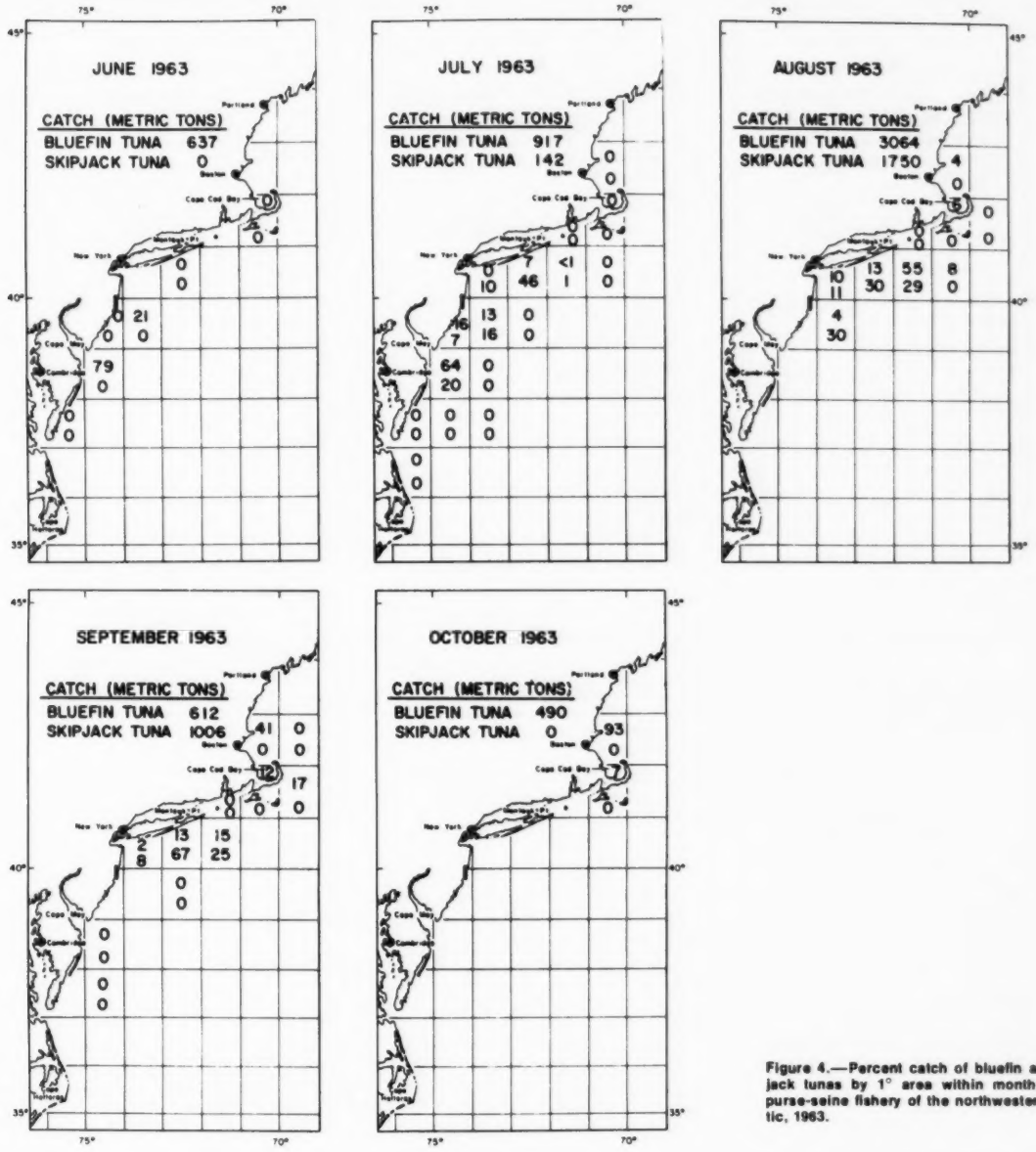


Figure 4.—Percent catch of bluefin and skipjack tunas by 1° area within month for the purse-seine fishery of the northwestern Atlantic, 1963.

6,200 tons in 1963, decreased to 1,100 tons in 1968, increased again to 4,800 tons in 1970, and declined to 2,400 tons in 1972 (Fig. 1).

Since 1960, more than 90 percent of the total annual landings of bluefin tuna made by Canadian and U.S. fishermen has been attributed to the purse-seine fishery. The purse-seine catch of bluefin tuna was 140 tons in 1958; it peaked in 1963 at 5,770 tons, declined substantially in 1968, and rose to another peak of 4,290 tons in 1970 (Fig. 2). The catch then declined to about 1,780 tons in 1973.

Skipjack tuna and small amounts of yellowfin tuna are also caught in the bluefin tuna fishery. The catches of tropical tunas, however, are usually a minor part of the total catch, although in 1964 the skipjack tuna catch of 4,970 tons was nearly equal to the bluefin tuna catch of 5,170 tons (Table 1).

The fishery operates during a short season, June through early October, with virtually all (90 percent or more) of the catch and effort concentrated in July and August (Fig. 3). Weather is believed to be an important determining factor for the short season. Availability is another. Apparently, changes in migration patterns influence the availability of bluefin tuna to the purse-seine fishery (Mather, Rothschild, Paulik, and Lenarz[5]). Wilson (1965) stated that the purse-seine fishing season was increased by expansion of the fishery into southern fishing grounds, where schooled fish are available earlier in

[5]Mather, F. J. III, B. J. Rothschild, G. J. Paulik, and W. H. Lenarz. Preliminary analysis of bluefin tagging data. Manuscript, 27 p. National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California 92037.

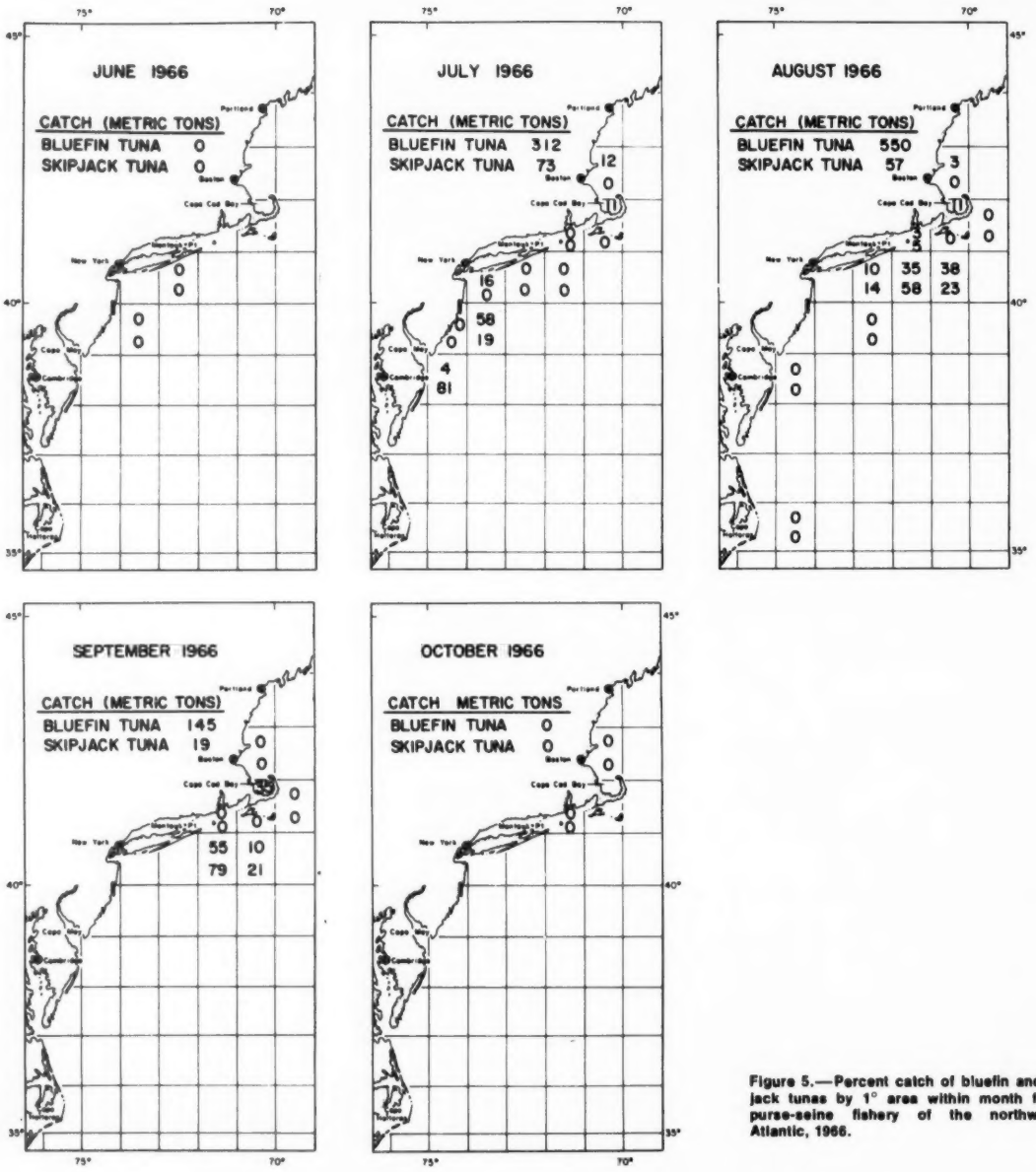


Figure 5.—Percent catch of bluefin and skipjack tunas by 1° area within month for the purse-seine fishery of the northwestern Atlantic, 1966.

the year than in the region north of Cape Cod.

During the early years, the 1950's and early 1960's, of the purse-seine fishery, a greater amount of the season's catch was made in September and October. The fishery during the early years was centered in Cape Cod Bay with little effort expended south of Martha's Vineyard (Wilson, 1965). In 1962, the fishery expanded south of Martha's Vineyard. Currently most of the bluefin tuna are caught in July and August off New Jersey and New York, perhaps before they can travel northeastward to be available in more northern waters in September or October (Sakagawa and Coan, Footnote 4; Mather et al, Footnote 5). Most current catches in September and October are made in Cape Cod Bay and consist of fish primarily larger than about 122 cm long. Generally, Cape Cod Bay is considered a good fishing ground for large bluefin tuna (Wilson, 1965).

The fishery operates within a small geographic area and the catch is obtained from only a few "key" 1° × 1° areas, those in which 20 percent or more of the bluefin tuna are caught in any one month. The percent catches in 1° × 1° areas by months for 3 years, 1963, 1966, and 1973 which represent years of peak catch (1963), low catch (1966), and recent catch (1973), are shown in Figures 4, 5, and 6. In June, there is not much fishing and usually only one or two key areas off the New Jersey coast are fished by the purse-seine fleet. In July, schooled bluefin tuna are caught in several key areas off New Jersey and Long Island, N.Y. between lat. 38°N and 41°N. In August and September,

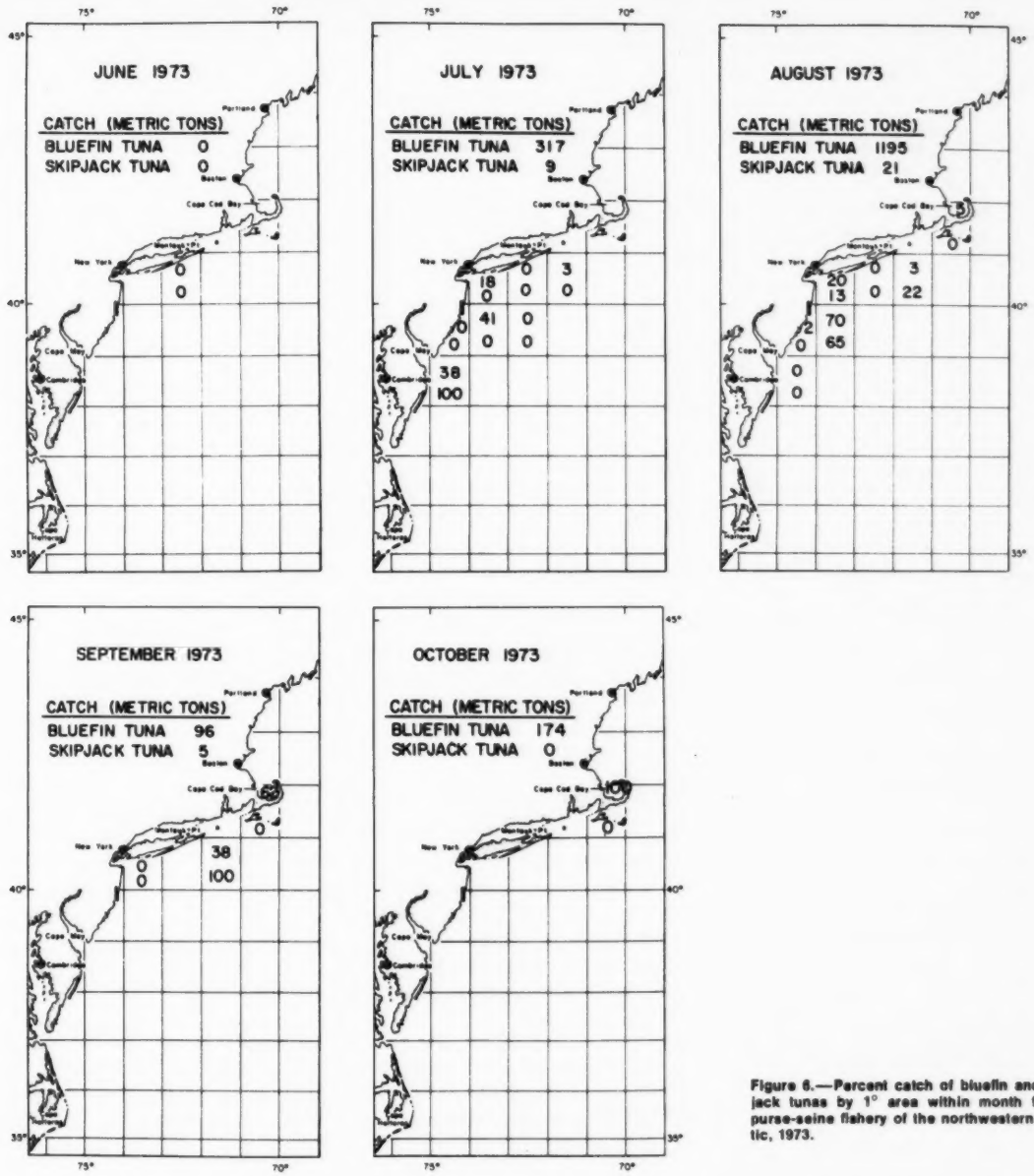


Figure 6.—Percent catch of bluefin and skipjack tunas by 1° area within month for the purse-seine fishery of the northwestern Atlantic, 1973.

the key areas are primarily off Long Island, although in 1963, substantial catches were made in a more northern area, off Boston, Mass. in September. Very little fishing is done in October because of poor weather conditions and availability. Catches during that month generally have been made off Rhode Island and Massachusetts and consist of larger fish (> 122 cm).

FISHING EFFORT

The number of vessels in the bluefin tuna purse-seine fishery increased from 1 boat in 1958 to 21 boats in 1964, and thereafter fluctuated between 4 and 13 boats, averaging about 9 boats fishing per year (Table 2).

Currently there are two major groups of seiners that participate in the fishery (Table 2). One group is seiners 92-181 tons capacity based primarily in New England ports which fish regularly for bluefin tuna in the northwestern Atlantic. Their trips seldom last more than a week. The second group is of seiners 364-1,000 tons capacity based in California, Puerto Rico, and New Brunswick, which fish irregularly in the northwestern Atlantic for tunas. Usually these large vessels enter the fishery only when tropical tuna fishing in the eastern Pacific or in the eastern Atlantic is poor. They are capable of remaining at sea for several months and usually return to their home ports to unload or for provisions.

Although there was a decrease of 14 boats (67 percent) in the fishery from 1964 to 1973, the carrying capacity of the fleet decreased only by 40 percent; the bluefin tuna catch decreased by 66 percent over the same period. The total carrying capacity of

Table 2.—Numbers and classes of purse seiners participating in the bluefin tuna fishery of the northwestern Atlantic Ocean, 1958-73.[1]

Year	Estimated total carrying capacity[2]	Class (carrying capacity[2]) 1 (0-45)	2 (46-91)	3 (92-181)	4 (182-272)	5 (273-363)	6 (364+)	Total
1958	40	1	-	-	-	-	-	1
1959	40	1	-	-	-	-	-	1
1960	40	1	-	-	-	-	-	1
1961	100	1	1	-	-	-	-	2
1962	1,000	1	2	2	1	1	-	7
1963	5,300	1	4	3	4	-	6	18
1964	8,100	1	4	3	2	2	9	21
1965	3,400	1	4	3	1	-	4	13
1966	900	1	2	3	-	-	1	7
1967	5,100	-	1	3	1	-	6	11
1968	700	-	1	3	1	-	-	5
1969	400	-	1	3	-	-	-	4
1970	3,500	-	1	3	-	-	4	8
1971	8,200	-	-	3	1	-	8	12
1972	6,200	-	-	3	1	-	7	11
1973	4,900	-	-	3	-	-	4	7

[1]Data are from the following sources: 1958-63 from Wilson (1965), 1964-73 from Mather F. J. III, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 (pers. commun.) Beckett, J.S., Fisheries Research Board of Canada, St. Andrews, N.B. (pers. commun.) and the Inter-American Tropical Tuna Commission, La Jolla, CA 92037.
[2]Carrying capacity in metric tons.

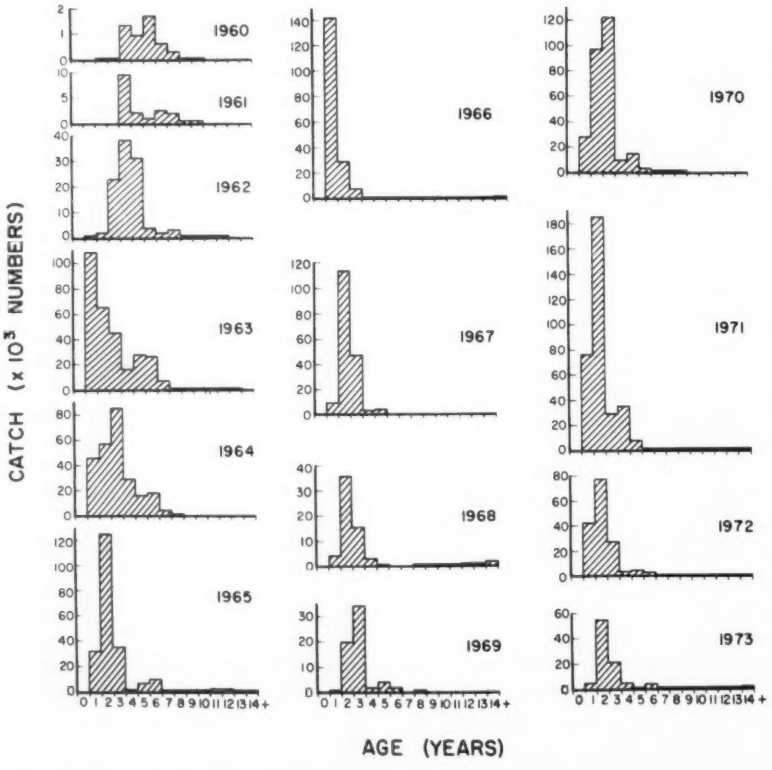


Figure 7.—Age composition of the purse-seine catch of bluefin tuna from the northwestern Atlantic.

the 1973 fleet was excessive in that it was about 4,900 tons, bringing in only 1,780 tons of bluefin tuna. It appears that the recent trend has been for larger but fewer boats in the fishery with a fleet carrying capacity in excess of the catch.

Data on nominal fishing effort in terms of fishing days have been collected from the bluefin tuna purse-seine fleet since the establishment of the fishery in 1958. It has been presented as effective effort (i.e. being proportional to instantaneous fishing mortality) in some published accounts (e.g. Aloncle, Hamre, Rodriguez-Roda, and Tiews, 1972; Lenarz, Jones, and Mather, 1972). Changes within the fishery, however, such as the entry of large seiners, the increased use of aircraft, and the southward expansion of the fishing grounds, have affected the fishing efficiency of the boats and the nature of the effort statistics collected through the years. For example, a unit of nominal fishing effort of a Class 3 seiner (92-181 tons) is not equal in terms of mortality generated to a unit of nominal fishing effort of a Class 6 seiner, (>364 tons), since Class 3 seiners more often use aircraft to aid in searching for schools and use smaller seines than do Class 6 seiners. Furthermore, Class 3 seiners were formerly in the unique position of being able to fish in both deep and shallow waters whereas larger seiners, with deeper nets, were able to fish only in deep water (Wilson, 1965). There has also been a change in the fishing effectiveness of perhaps all boats as the captains and crews became more proficient in the fishing techniques (Wilson, 1965), but particularly in that of Class 3 seiners as they increased their dependence on aircraft to locate schools and to assist in positioning the net. Because of these changes in the efficiency of the vessels, nominal fishing effort for the fleet is not a reliable measure of effective effort from one year to another.

AGE COMPOSITION OF CATCH

Sakagawa and Coan (Footnote 4) estimated the age composition of the purse-seine catch for 1960-72. I estimated the composition for the 1973 catch using that method. The results show three phases in the development of the purse-seine fishery (Fig. 7). The first was in 1960-62 when age groups

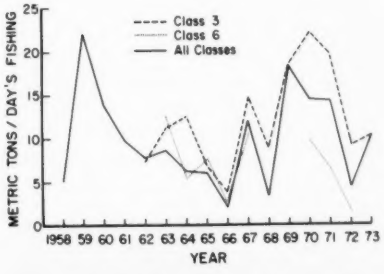


Figure 8.—Nominal catch rates by class of vessel in the purse-seine fishery for bluefin tuna in the northwestern Atlantic.

3-6 years dominated the catch. A transition phase followed in 1963 and 1964 when the catch was dominated by a combination of younger fish as well as 3-year old to 6-year old fish. The last phase began in 1965 when the young age groups (1-3 years) dominated the catch with few older fish represented. In 1973 the average length of bluefin tuna in the catch was 89 cm, whereas it was 140 cm in 1960.

The changes in the age composition of the catch should be recognized as influenced in part by the southward expansion of the fishing grounds. In the early stages of the fishery's development, the fishery was centered north of Cape Cod, where primarily large fish are available (Wilson, 1965). As the fishery expanded southward, beginning in 1962, into areas where younger fish are more available, more smaller fish were caught (Sakagawa and Coan, Footnote 4; Mather et al, Footnote 5). Finally, in the last phase the fishery was centered off New Jersey-New York, where primarily young bluefin tuna are found.

CATCH RATE

Most published catch rates (CPUE) for the northwestern Atlantic purse-seine fishery for bluefin tuna are based on total days fishing or total nominal effort (Fig. 8). As was stated above, nominal effort is not a reliable measure of effective effort, hence fishing mortality, because of changes, particularly in efficiency, of the vessels over the years. Consequently, the nominal CPUE's in Figure 8 are likewise unreliable for indexing abundance unless change in vessel efficiency is taken into account.

Sakagawa and Coan (Footnote 4) indicated that vessel efficiency, at least for Class 3 vessels, probably has increased since the mid-1960's when vessels began relying more heavily on aircraft to locate schools and cooperating more fully among themselves in fishing operations. In Figure 8, the nominal CPUE's for Class 3 vessels since the mid-1960's are therefore probably overestimated and should be adjusted downward to reflect the increase in vessel efficiency. The CPUE's for the 1970's would then indicate a more pronounced decline than depicted in Figure 8.

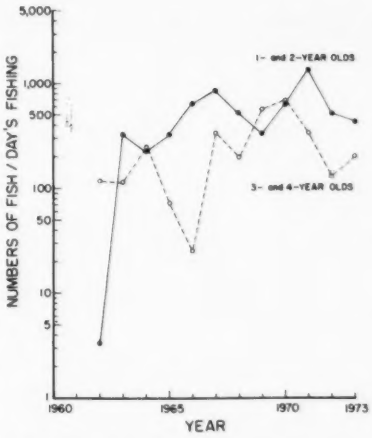


Figure 9.—Nominal catch rates of 1- and 2-year old and 3- and 4-year old bluefin tuna for Class 3 vessels in the purse-seine fishery for bluefin tuna in the northwestern Atlantic.

The CPUE's for Class 3 vessels in terms of numbers of fish are shown in Figure 9. Only CPUE's for age groups 1 and 2 and 3 and 4 are shown. These age groups represent sizes of fish (< 140 cm) that are most sought after by the purse-seine fishermen. The CPUE's have not been adjusted for changes in vessel efficiency. They nevertheless indicate that apparent abundance of age groups 1-4 was at a high level and the CPUE of 3- and 4-year olds was less than that of the recruits, 1- and 2-year-old fish, in most years.

In the 1970's, the general trend of CPUE's for both the recruits and 3- and 4-year olds is downward, although the CPUE of recruits somewhat leveled off and that of 3- and 4-year olds increased in 1973. This declining trend is probably associated with changes in survival and availability of recruits and changes in the abundance of the spawning stock.

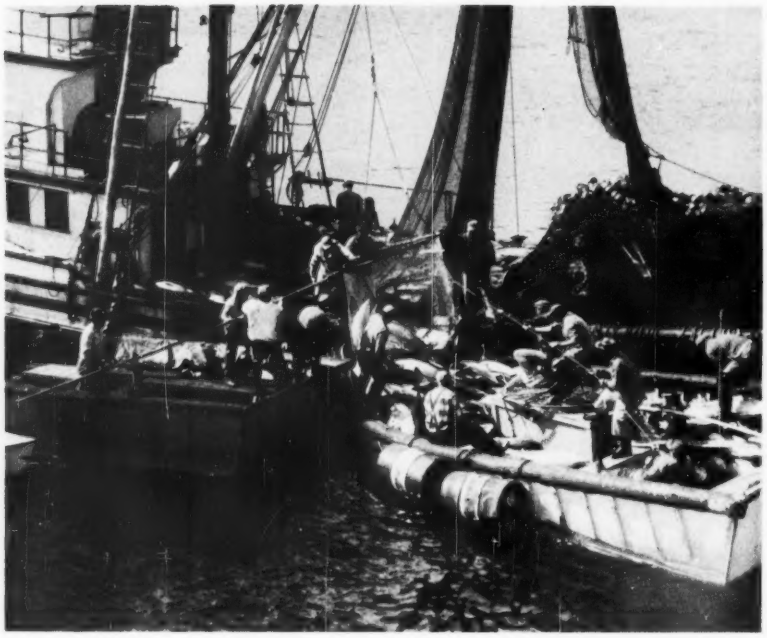
DISCUSSION

The bluefin tuna catch of the purse-seine fishery of the northwestern Atlantic ranged from 138 tons in 1958, the year the fishery was established, to 5,770 tons in 1964. The most recent catch was 1,781 tons. The fluctuations in catch are possibly due to (1) variation in migration patterns (Mather et al, Footnote 5) and location of the fishery, (2) variation in the amount of effective effort used to bring the catch, (3) variation in recruitment or stock abundance, and (4) variation in fishing effort of the sport fishery, which competes with the seine fishery for bluefin tuna, or a combination of any of these.

Besides the purse-seine and sport fisheries of the northwestern Atlantic, commercial fisheries in the Bay of Biscay, off Portugal, and off northern Africa also catch small Atlantic bluefin tuna (50-122 cm long) during the summer and fall. There is uncertainty as to whether these widely separated fisheries normally exploit fish from separate stocks or from a common stock. Tagging experiments, however, have demonstrated that, at least in some years, fish of similar stocks are exploited in the eastern and western Atlantic (FAO, 1972). Mather, Bartlett, and Beckett (1967), for example, examined tagging data and hypothesized that between the summers of 1965 and 1966 there was sufficient migration of young bluefin tuna from west to east to cause a decline in catch from the northwestern Atlantic and a concomitant increase in catch from the Bay of Biscay. Aloncle[6] concluded from tag returns of small bluefin tuna tagged in the eastern Atlantic that independent American and European stocks exist but that east-west migration does occur. Thus, the degree of transatlantic migration has at least in some years affected the catch from the northwestern Atlantic.

Tagging studies have also demonstrated that in the northwestern Atlantic changes in migration pattern with age of fish affect the availability of different age groups of bluefin tuna to the purse-seine fishery (Mather et al., Footnote 5). Mather et al., (Footnote 5) found that a higher proportion of tagged 1.4-year old bluefin tuna returned to the fishing area off the United States east coast the year after their release than did older fish. Since the age groups represented in the purse-seine catch have varied, availability of the different age groups has probably contributed to the variation in the catch. Of course, superimposed on this effect of variable availability is the effect of variable year-class strength, which would also contribute to variation in catch.

[6]Aloncle, H. Marquage de thons rouges dans le Golfe de Gascogne. Manuscript, 11 p. Institut des Pêches Maritimes, La Noë-Route de la Janelière, 44-Nantes.



Brailing bluefin tuna from a purse seine net off the U.S. east coast.

Trends in the nominal fishing effort for the purse-seine fishery suggests that total effective effort has fluctuated owing to changes in the number, size, and efficiency of vessels in the fleet. The fluctuation, of course, contributed to the variation in the purse-seine catch.

Class 3 nominal catch rates for the 1970's are overestimated relative to those of earlier years because of improved fishing efficiency since the mid-1960's. When improved efficiency is taken into account, a declining trend prevails in the catch rates for the 1970's; the current catch rate is low, perhaps at the lowest level since the establishment of the fishery. Thus, the catch rates of the 1970's suggest that the stocks fished by the fishery possibly declined in abundance or availability, which has contributed to the recent decline in the purse-seine catch.

Finally, sport fishermen in the northwestern Atlantic compete with seine fishermen for bluefin tuna. Although the total sport catch of schooled bluefin tuna is not known, rough estimates (Sakagawa and Coan, Footnote 4) suggest that the catch was large enough in some years to have an impact on the purse-seine catch.

ACKNOWLEDGMENTS

I wish to thank the following individuals for providing information used in this report: F. J. Mather III and J. M. Mason, Jr. of the Woods Hole Oceanographic Institution; J. S. Beckett of the Canadian Fisheries and Marine Service; and B. G. Thompson of the National Marine Fisheries Service. The generous cooperation of the captains and owners of American tuna vessels that fish in the northwestern Atlantic and tuna canneries on the east coast of the United States and in Puerto Rico is acknowledged. The Inter-American Tropical Tuna Commission and the Woods Hole Oceanographic Institution collected part of the data used in this report under National Marine Fisheries Service contracts.

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MFR PAPER 1127

An Assessment of the South Pacific Albacore, *Thunnus alalunga*, Fishery, 1953-72

ROBERT A. SKILLMAN

ABSTRACT—As the amount of fishing effort expended in the South Pacific albacore, Thunnus alalunga *(Bonnaterre), fishery increased markedly from the mid-1960's through the early 1970's, measures of apparent abundance of albacore declined by more than 60%. Preliminary estimates of catch per unit effort for the first half of 1974 set new records, alarmingly low ones. Because of these factors and because of proposed further increases in harvesting pressure, an assessment of the fishery is needed. The albacore resource is assessed in this paper by using the generalized production model of Pella and Tomlinson. Using two measures of fishing effort, the maximum sustainable "average" yield is estimated to be 33,000-35,000 metric tons. Based on the generalized production model, a 25% increase in fishing effort over the 1971 level will result in a moderate increase in catch, 300 metric tons, or a substantial decline in catch, 6,700 metric tons, depending on the measure of fishing effort used.*

INTRODUCTION

The development of the South Pacific fishery for albacore, *Thunnus alalunga* (Bonnaterre), in its entirety and in particular that segment based in American Samoa has been described in detail by Otsu (1966) and Otsu and Sumida (1968). Their descriptions have been summarized and updated in the following paragraph.

Before the 1940's there was virtually no longline fishing in the South Pacific Ocean. After the ratification in April 1952 of the Peace Treaty between the United States and Japan, the Japanese began fishing in the western South Pacific near the Solomon Islands, principally for yellowfin tuna, *Thunnus albacares* (Bonnaterre). By late 1952, the Japanese had sent fishing expeditions as far south as lat. 15°S, and by 1953-54 they had extended their operations to lat. 25°S in the western Pacific. In 1953, a California tuna-packing firm bid for and obtained a lease from the U.S. Department of the Interior on a defunct cannery that had been built in Pago Pago, American Samoa in 1949 (Van Campen, 1954). In January 1954, seven Japanese tuna vessels began longline fishing in the vicinity of American Samoa to supply tuna for this cannery, thus establishing the albacore fishery in the South Pacific. This fishery has expanded over the years with the growth of the operations in American Samoa (Fig. 1), the increase in home-based fleets of Japan, Korea, and Taiwan, and the establishment of new bases in the South Pacific. A base was established at Espíritu Santo in the New Hebrides in 1958 and at Levuka in the Fiji Islands in 1963. Also in 1963, a second California tuna-packing firm began operations in American Samoa. The latest development occurred in 1971 when a transshipment base was established in Tahiti. Very small surface fisheries exist in Australia and New Zealand but were not considered in this paper.

In the Samoan fishery, the catch of yellowfin tuna slightly exceeded that of albacore in 1954 and 1955; thereafter, albacore has been dominant in the catch (Fig. 2). Albacore catches reached a peak in 1967 and have since declined. Catches of yellowfin tuna increased throughout the history of the fishery and remained second to albacore in all but 3 years. Catches of bigeye tuna, *Thunnus obesus* Lowe, reached a peak in 1967, when they exceeded yellowfin catches, and declined steadily through 1971. Catches of billfishes were never significant in

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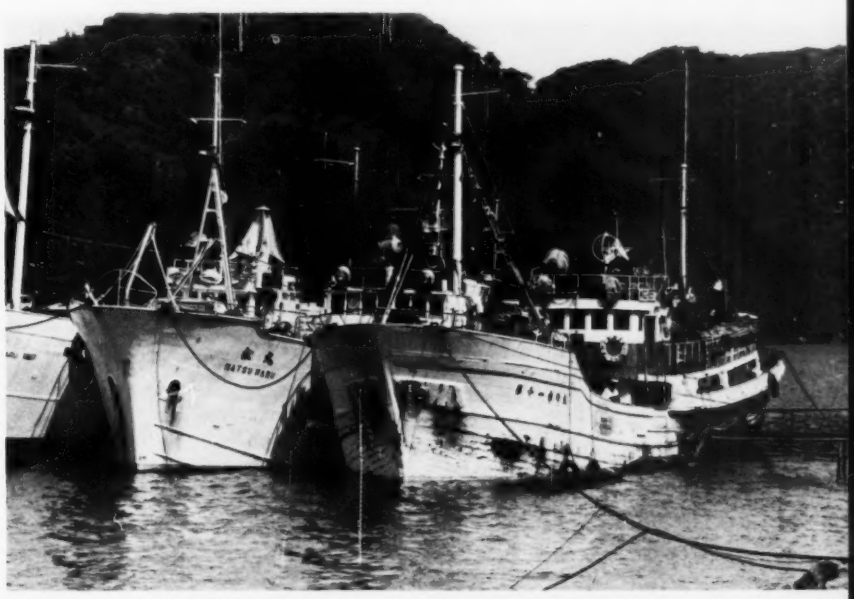

Pago Pago harbor and three typical Japanese longliners.

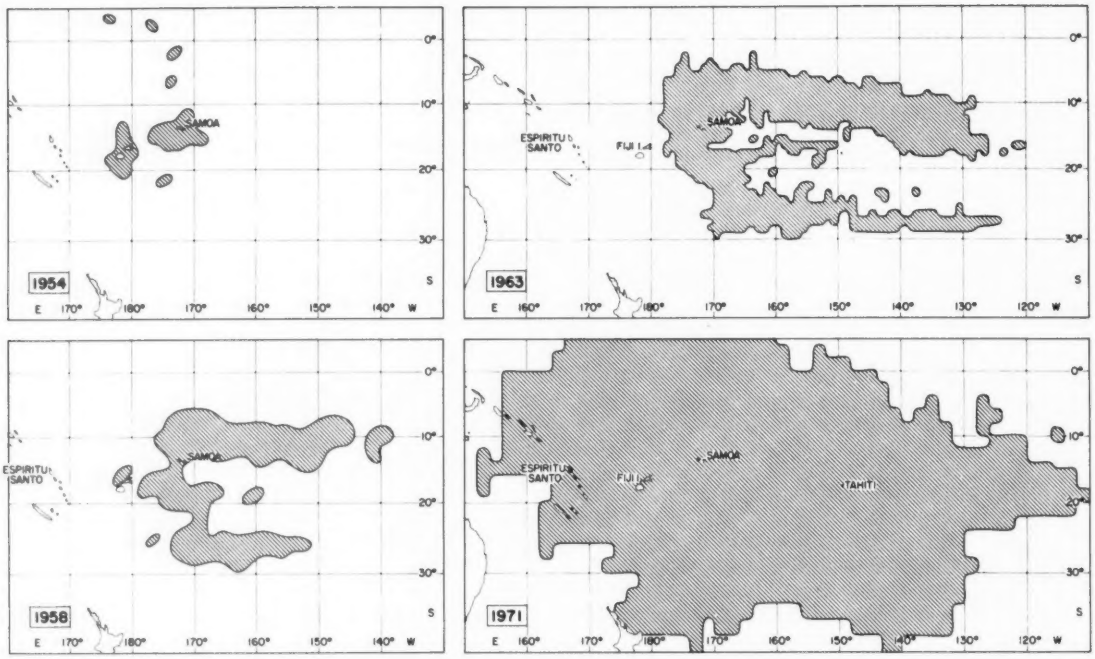

Figure 1.—Areas fished (hatched) by the longline fleet based in American Samoa in 1954, 1958, 1963, and 1971 as well as the location of longline bases (island names) in the South Pacific.

the Samoan fishery. The species trends shown in Figure 2 are not directly comparable because albacore were weighed in the round while yellowfin and bigeye tunas were weighed gilled and gutted and billfish weights were for fillets.

Other biological and fishery information relating to South Pacific albacore may be found in Isii and Inoue (1956), Koga (1961, 1962), Otsu and Hansen (1962), Yoshida and Otsu (1963), Yoshida (1965, 1971), Ishii (1967), Nakagome (1969), and Grandperrin and Legand (1971). A colorful description of the various fisheries in American Samoa, including the longline fishery for albacore, may be found in Otsu and Yoshida (1971).

Plans to expand fishing operations in Tahiti and to establish a third cannery in American Samoa stimulated this production model assessment of: 1) the effects of the fishery on the albacore population and 2) the biological potential for expansion of the fishery. In order to produce this assessment on a timely basis, first approximations of total catch for the entire South Pacific were used and the effort statistics were treated in a cursory fashion.

Since total catch data for the entire South Pacific and appropriate effort data from the fishery in American Samoa were available from 1962 to 1971, the production model assessment was limited to those years. However, those statistics that were available through 1972 were included in the figures so that as current a picture of the fishery as possible could be presented.

SOURCE DATA

Fishing Effort

For the vessels based in American Samoa, fishing effort has been measured in terms of the number of vessels fishing, size of vessels, number of trips, number of days fished, and number of hooks fished. Each of these

Unloading operations on a small longliner. Here one deckhand unties a rope used to haul several frozen fish out of the hold while another lifts a large yellowfin tuna out by hand.

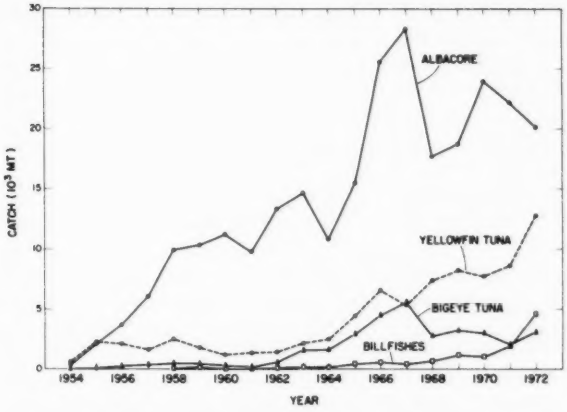

Figure 2.—Total catch in metric tons (MT) by species and by year of capture, 1954-72, for the fishery in American Samoa.

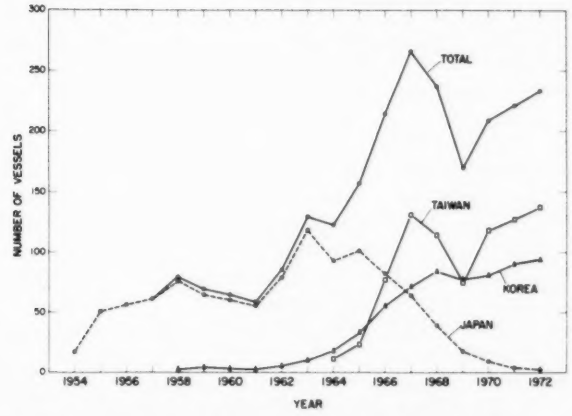

Figure 3.—The number of vessels, by nationality, fishing in the long-line fishery based in American Samoa, 1954-72.

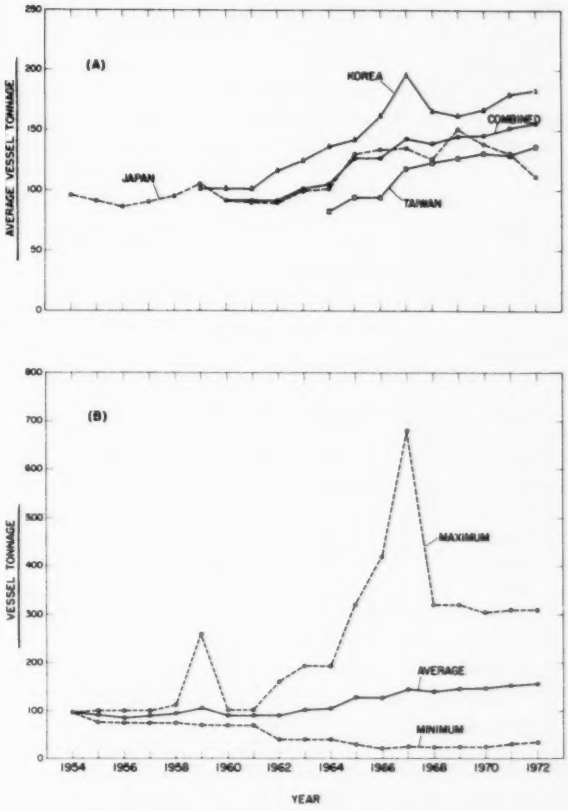

Figure 4.—Vessel tonnage for the fishery in American Samoa. A. Average vessel tonnage by nationality and for all nations combined (including those of undetermined nationality). B. Maximum, average, and minimum vessel tonnage for all nations combined (also including those of undetermined nationality).

measures will be presented to illustrate the historical development of the fishery while the latter two measures will also be used in the assessment of the effect of the fishery on the albacore population. Measures of fishing effort were available for home-based fleets of Japan, Korea, and Taiwan but were not used in this report because: 1) the percent of trips covered for some nations was low, 2) the time series was too short or interrupted for some nations, 3) albacore catches were usually incidental to fishing directed toward other tunas, and 4) these data would have had to be standardized to the Samoan data in any case.

Effort measured in number of vessels was obtained from cannery records and represents a complete sample of the fleet (Fig. 3). From a low of 18 vessels in the first year of the fishery, 1954, the number of vessels operating in the fishery increased steadily to a peak of 266 in 1967. This peak was a result of increasing representation of Korean and Taiwanese vessels and a fairly large component of Japanese vessels, although Japanese representation was actually decreasing at the time. The decline following 1967 resulted from the continued withdrawal of Japanese vessels and some contractual problems with the remaining vessels. In 1970-72, the number of vessels in the fleet again increased. In addition to this increase in number, the average size of vessels increased steadily from a low of 86 gross tons in 1956 to 156 gross tons in 1972 (Fig. 4). The maximum and minimum vessel tonnages have shown marked yearly fluctuations. The maximum increased from a low of 96 gross tons in 1954 to a peak of 680 gross tons in 1967 and stabilized at about 310 gross tons between 1968 and 1972.

Loading fish at a Samoan cannery.

The minimum decreased from a high of 96 gross tons in 1954 to a low of 20 in 1966.

The number of fishing trips made by the Samoan fleet was obtained from cannery records and represents a total sample of the fleet (Fig. 5). It has shown a highly oscillatory pattern over the history of the fishery. The number of trips made by Japanese vessels increased rapidly from 1954 to 1958, declined until 1961, increased to a peak in 1963, and declined steadily throughout the remaining years. Korea entered the fishery in 1958, but the number of fishing trips did not increase substantially until 1963. In 1964, Taiwan entered the fishery and has shown a rapid increase in fishing effort. The time trend for trips followed the same general pattern as that for number of vessels up to the peak in 1967. Trips by Taiwanese vessels showed the same decline in the late 1960's and rise in the early 1970's as the number of Taiwanese vessels; however, Korean trips showed a steady increase until 1969. The result was that the number of trips seemed to be stabilized whereas the number of vessels was increasing.

Data on the number of days spent fishing by each nation in the Samoan fleet (Fig. 6) from 1957 through part of 1972 were collected from cannery records. These data followed the same general trends shown by the other measures of effort, except for the last few years. This measure of fishing effort indicated that fishing intensity increased through 1972, when fishing effort exceeded that in the peak catch year 1967.

Because logbook records were obtained from a different proportion of the fleet each year, the number of hooks fished for 1960-72 was estimated from total catch, number of albacore per 100 hooks, and average weight of albacore in the fishery. Although it appeared that the Samoan fleet may have been directing an increasing amount of effort toward yellowfin tuna, fishing effort was not adjusted to take this potential effect into consideration. The numbers of hooks fished were at a low level in the early years but increased rapidly through 1967 (Fig. 7). The decline in number of hooks in 1968 resulted primarily from the withdrawal of Japanese vessels from the fishery. Following this decline, there seemed to be a leveling of effort at about 36 million hooks, which agrees with the trend shown by the number of trips but neither with the number of vessels nor with the number of days fished.

Total Catch

Catch data for the South Pacific longline fishery were obtained from cannery reports in American Samoa for 1954-72, from Fisheries Agency of Japan, Research Division (1965, 1966, 1967a, 1967b, 1968, 1969, 1970, 1971, 1972, 1973, 1974) for 1962-72, and from the Federation of Japan Tuna Fisheries Cooperative Associations and Japan Tuna Fishermen's Cooperative Association (1967-72) (hereafter referred to as the Asian Tuna Conference proceedings) for 1962-71. These data (Fig. 8) were used in the fitting of the generalized production model. Catch data for Japanese operations for the years 1953-59 and 1961 were obtained from Tuna Fishing (published monthly by the All Japan Investigative Conference of Tuna, Misaki Branch, c/o Kanagawa Prefectural Fisheries Experimental Station, Misakimachi, Miura-shi, Kanagawa, Japan) and presented in Figure 8 to give some idea of the trends in catches for that portion of the fishery not operating out of American Samoa. However, since these latter data were incomplete to an unknown degree, they were not used in fitting the generalized production model.

In order to convert catch reported in numbers to catch in weight, average weight was calculated using data from the Samoan fishery (Fig. 9). These averages were calculated in kilograms for 1962 through 1972 by "South Pacific Ocean Region" and "Eastern Pacific Ocean Region" as defined by the Fisheries Agency of Japan, and for the entire South Pacific (a weighted average). The average size of albacore has decreased in the "South Pacific Ocean Region" where most of the fishing effort has been expended, but this decrease in size may be due to the expansion of the fishery southward where small albacore occur. In the "Eastern Pacific Ocean Region" where the Samoan fleet fishes only seasonally and then only recently and where home-based foreign fleets fish mostly for yellowfin and bigeye tunas, the average weight showed no trend over years.

In the early years of the fishery up

Table 1.—Albacore catch in metric tons (MT) for the South Pacific Ocean. Catches in parentheses were estimated from 1970 catches (and 1971 average fish weights for Japan) because 1971 data were not available.

Year	Category	Catch (MT)				CPUE		Estimated total effective effort	
		Japan	Korea	Taiwan	Total	MT/10^3 hooks	MT/*day*	Hooks ($\times 10^6$)	Days ($\times 10^3$)
1962	Nation	28,352	—	298	28,650			19.267	17.517
	American Samoa				13,326	1.4870	1.6356	8.962	8.147
	Grand total				41,976			28.229	25.664
1963	Nation	23,762	—	608	24,370			25.296	20.281
	American Samoa				14,650	0.9634	1.2016	15.207	12,192
	Grand total				39,020			40.503	32.473
1964	Nation	14,136	—	73	14,209			16.857	12.671
	American Samoa				10,791	0.8429	1.1214	12.802	9.623
	Grand total				25,000			29.659	22.294
1965	Nation	10,871	—	50	10,921			14.097	10.535
	American Samoa				15,459	0.7747	1.0366	19.955	14.913
	Grand total				26,380			34.052	25.448
1966	Nation	16,534	0	0	16,534			18.918	15.512
	American Samoa				25,570	0.8740	1.0659	29.256	23.989
	Grand total				42,104			48.174	39.501
1967	Nation	9,670	1,306	604	11,580			15.785	12.086
	American Samoa				28,310	0.7336	0.9581	38.591	29.548
	Grand total				39,890			54.376	41.634
1968	Nation	5,413	1,262	4,206	10,881			19.719	15.321
	American Samoa				17,723	0.5518	0.7102	32.119	24.955
	Grand total				28,604			51.838	40.276
1969	Nation	4,489	4,924	3,398	12,811			22.111	16.256
	American Samoa				18,731	0.5794	0.7881	32.326	23.767
	Grand total				31,542			54.439	40.023
1970	Nation	5,598	4,673	3,707	13,978			24.570	16.206
	American Samoa				23,876	0.5689	0.8625	41.969	27.682
	Grand total				37,854			66.539	43.888
1971	Nation	(6,437)	(4,673)	5,863	16,973			31.052	23.639
	American Samoa				22,193	0.5466	0.7180	40.602	30.909
	Grand total				39,166			71.654	54.548

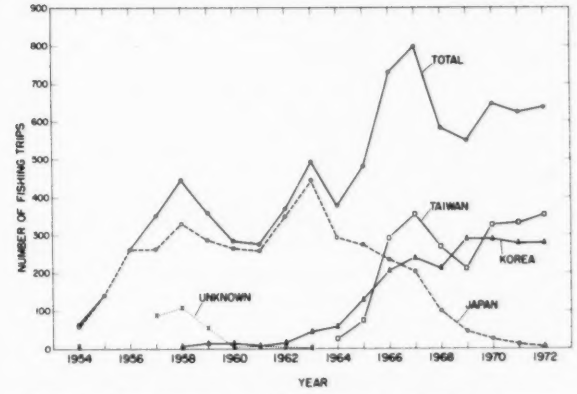

Figure 5.—Total number of fishing trips by nationality of vessels for the fishery based in American Samoa, 1954-72.

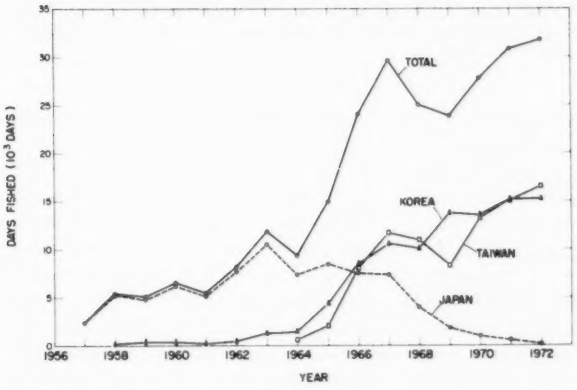

Figure 6.—Total number of days fished, by nationality of vessels, for the fishery based in American Samoa, 1957-72.

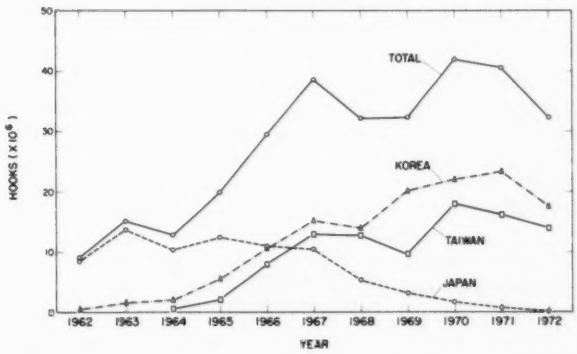

Figure 7.—Effort in hooks by nationality of vessel for the fishery based in American Samoa, 1960-72.

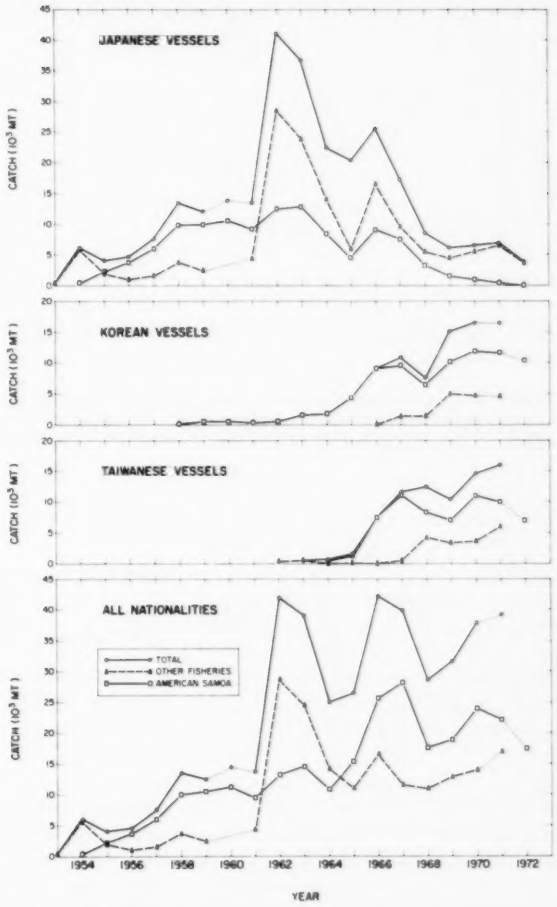

Figure 8.—Catch of albacore by nationality of vessels for the fishery in American Samoa and all other fisheries in the South Pacific. Dotted lines were used where data were missing or where catches were estimated from incomplete data.

through 1961, it appeared that the Samoan fishery constituted the major portion of the South Pacific albacore fishery (Fig. 8); however, these data were apparently incomplete and, therefore, not fully reliable. In 1962, when reliable data became available, the Samoan operations accounted for only 31.7 percent of the total catch. The actual catch and the proportion of the catch landed by the Samoan fleet increased steadily through 1964, when the proportion reached 58.6 percent, until 1967 when the fleet accounted for 71.0 percent of the catch. Following 1967, the Samoan operations accounted for about 60 percent of the total catch. This decrease in dominance of the Samoan fleet was due mainly to increased catches by other fleets.

Catches of albacore by Japanese vessels based in Samoa and elsewhere increased from 1953 through 1962, decreased through 1969 as the vessels withdrew from the albacore fishery. Incidental catches of albacore increased slightly in 1970-72. Catches of albacore by Korea and Taiwan seemed to have stabilized after an initial growth phase when they entered the fishery. For both nations, the operations based in American Samoa accounted for the largest share of their albacore catches.

ANALYSIS

Index of Relative Abundance

Index of relative abundance or catch per unit of effort (CPUE) for the fishery based in American Samoa was calculated in terms of catch in numbers of albacore per 100 hooks

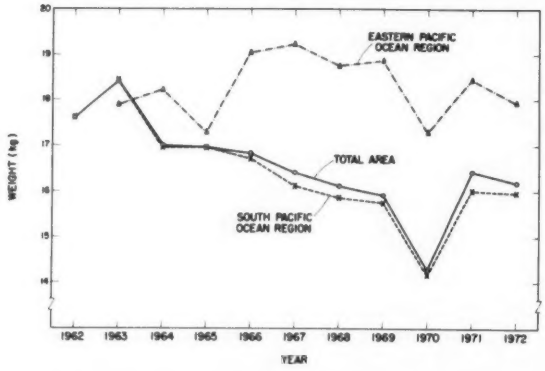

Figure 9.—Average weight of albacore for the year of capture by ocean area using data from the Samoan fishery. The 1971 and 1972 weights were estimated from actual length measures and historical trends in condition factor.

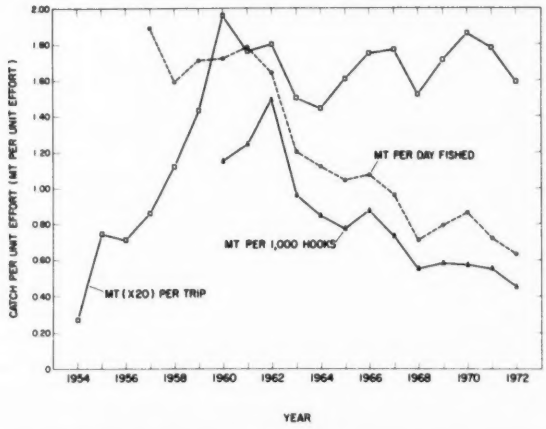

Figure 10.—Annual estimates of indexes of population abundance (CPUE) of albacore in terms of metric tons (MT) per trip, per day fished, and per 1,000 hooks as determined for the fishery based in American Samoa.

(converted to metric tons per 1,000 hooks), in metric tons per day fished (Table 1), and in metric tons per fishing trip. All indexes of relative abundance were calculated as ratio of averages estimators for each year (total catch divided by total effort).

CPUE in trips did not exhibit the same trend with time as the other indexes of abundance (Fig. 10) and was not, I felt, a valid measure of albacore abundance. The increasing CPUE in trips from 1954 through 1960 was probably due to an increase in days fished per trip as the fishery expanded into new grounds (Otsu and Sumida, 1968). Following 1965, at least until 1969, the fishery continued to expand but not as rapidly as in the preceding years (Yoshida[1]). Hence, the fluctuations seen over this time period were probably the result of a decreasing population density, a slight increase in the proportion of the population being harvested due to an expansion of the fishing grounds, a decrease in number of trips, and an increase in the number of days fished per trip. Because of these complications in the interpretation of the historical trend in these data, CPUE in trips was not used in fitting the generalized production model.

CPUE in days fished and CPUE in hooks fished followed similar trends with time, except in 1960-61. Differences in these early years were ascribed to errors in CPUE in hooks since this statistic was estimated from 2.5 percent and 8.1 percent of the total trips made by the fleet. Because of these differences and because CPUE in days fished was calculated from a complete sample of the fleet for all years, CPUE in days fished was considered the more accurate index of relative abundance. For comparative purposes, however, both of these indexes of abundance were used to estimate total effective effort and to calculate the generalized production model.

Total Effective Effort

The estimates of total effective effort, in terms of hooks and days fished by the Samoan fleet, expended in catching albacore in the South Pacific were calculated using total catch data and CPUE statistics derived in previous sections (Table 1). Since Samoan logbook records giving counts of hooks were a subsample of the whole Samoan fleet, estimates of effective effort were calculated for the Samoan fishery as well as for the catch outside the Samoan fishery. Total effective effort was obtained by summing these two estimates. Hence, by using the CPUE statistics calculated for the Samoan fishery, the effort expended by the Japanese, Korean, and Taiwanese fleets not based in Samoa was standardized in terms of the albacore fishery in American Samoa. Since Japanese vessels seemed to direct much of their effort toward southern bluefin tuna, *Thunnus maccoyii* (Castelnau), and bigeye tuna, the estimated number of hooks should have been much less than was actually fished. The same should have been true for Korean and Taiwanese data but to a lesser degree because a smaller proportion of their fishing seemed directed toward other species.

The amount of fishing effort expended by the non-Samoan fleet fluctuated from year to year but seemed to remain at about the same level from 1962 to 1970. In 1971, there may have been a trend upward in fishing effort. Over this same 10-year period, the effort expended by the Samoan fleet increased markedly (about 450 percent). The result of these two trends was that the total effective effort expended in the capture of albacore increased by about 250 percent.

Generalized Production Model

Although a wealth of biological knowledge on the South Pacific albacore does not exist and in particular information is lacking on mortality, individual growth, and recruitment that is required to use a dynamic pool model (Beverton and Holt, 1957; Ricker, 1958), there nonethless is a need to assess the state of the stock. Therefore, the generalized production model of Pella and Tomlinson (1969), requiring only catch and effort data, was used in this paper. However, this

[1]Yoshida, H. O. The American Samoa Long-line Fishery, 1966-71. Manuscript.

model makes several assumptions regarding population processes and handling of effort data in order to allow for the simplification of certain dynamic processes of populations. These assumptions are as follows: 1) The population is a closed, distinct, self-sustaining unit. It is generally believed that there are separate albacore populations in the North and South Pacific for the following reasons: a) areas of high catches or catch rates do not straddle the equator, b) areas of peak catches in both the North and South Pacific occurring in their respective winter months are at the poleward extremes of the fishery and then tend to move to middle latitudes as "summer" approaches, c) albacore of all ages are apparently in both the North and South Pacific, d) spawning seems to occur in the North Pacific in areas and seasons that are distinct from spawning in the South Pacific, e) no albacore tagged in the North Pacific have ever been recaptured in the South Pacific. As on any question, there is no uniformity of opinion here. Grandperrin and Legand (1971) argued on the basis of limited experiments with deep-fishing vertical longline gear in waters near New Caledonia (lat. 12°-23°S) and in French Polynesia (lat. 10°-25°S) that it is possible for the exchange of small fish as well as large fish across the equator. Their hypothesis is based on high catch rates of large fish at 200-300 m (greater than in the traditional grounds above 150 m) and on the occurrence of two small albacore (4.0 and 9.5 kg) at these depths in the experiments near New Caledonia. More work needs to be done in this area (see also Saito, 1973). 2) The concept of equilibrium holds for the South Pacific albacore. I do not suggest that the population is necessarily in equilibrium but rather that the population always tends toward a stable population size in response to changes in mortality (primarily fishing effort). 3) Although I assume that the concept of equilibrium holds, I do not assume that equilibrium is reached instantaneously with changes in fishing effort. The age of maturity for albacore is sufficiently old and the albacore contributes significantly to the fishery for so long that I feel it is unreasonable to expect the population

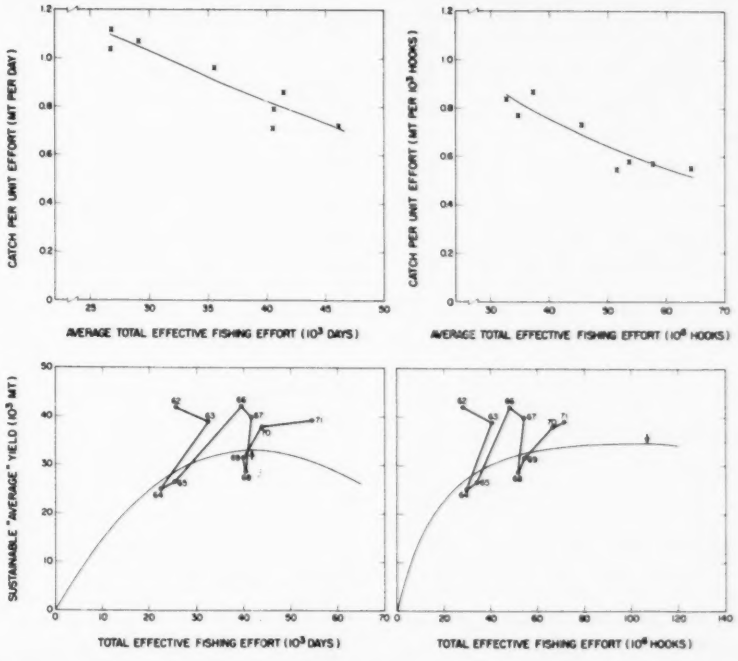
CATCH PER UNIT EFFORT (MT PER DAY)
AVERAGE TOTAL EFFECTIVE FISHING EFFORT (10³ DAYS)
CATCH PER UNIT EFFORT (MT PER 10³ HOOKS)
AVERAGE TOTAL EFFECTIVE FISHING EFFORT (10⁶ HOOKS)
SUSTAINABLE "AVERAGE" YIELD (10³ MT)
TOTAL EFFECTIVE FISHING EFFORT (10³ DAYS)
TOTAL EFFECTIVE FISHING EFFORT (10⁶ HOOKS)

Figure 11.—Plots of catch and fishing effort data for the South Pacific albacore fishery showing the equilibrium relationship between CPUE and fishing effort and the relationship between sustainable "average" yield and fishing effort for the generalized production model with effort data in terms of number of days fished and number of hooks fished and with an averaging time ($\overline{T}_i$) equal to 3 years. Arrows indicate location of MSAY (Maximum Sustainable "average" yield) on the stock production curves.

to respond instantaneously to changes in fishing effort. Hence, Gulland's procedure (Gulland, 1969, p. 120), which averages fishing effort over some mean time period during which a year class contributes significantly to the catch, was used to adjust for non-instantaneous response of the population to changes in fishing effort. 4) I have assumed that the catchability coefficient, q, is constant. There is no evidence that any gear modification, change in the nationality of the fleet, or change in species sought has caused any change in q.[2] The possibility of changing q as the fishery has expanded into new grounds, some of which yield fish smaller than the average size in the fishery, has not been investigated. 5) Sufficient data are available over a time period when a large population change occurred (a reduction of 56-62 percent in relative abundance over an 11-year period) so that the parameters of the production model can be estimated efficiently.

The generalized production model of Pella and Tomlinson (1969) was obtained for the South Pacific albacore fishery by entering catch in metric tons and effort in both number of days fished and number of hooks fished into PRODFIT, a least squares nonlinear regression algorithm using Gulland's equilibrium approximation technique (Fox, 1972). Four parameters of management interest were derived from the model using PRODFIT, namely $\overline{m}$, CPUE_{opt}, f_{opt}, and MSAY. The phrase maximum sustainable "average" yield (MSAY) was substituted for the well-known phrase maximum sustainable yield (MSY) to denote that the sustainable yield will fluctuate even though fishing effort and the catchability coefficient remain constant. The least squares procedure finds a solution of the general production model, using CPUE as the dependent variable, that results in the smallest residual sum of squares compared to all other possible solutions. Thus, this solution is a measure of central tendency, but not a true average. Calculating the curve of

[2]Skillman, R. A. 1974. Further investigations on the population dynamics of the South Pacific albacore fishery. Unpublished report filed at the Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu Laboratory, Honolulu, HI 96812.

Table 2.—Generalized production model for the South Pacific albacore fishery, 1962-71.

$\bar{T}_i$	$\hat{m}$	$\widehat{CPUE}_{opt}$	$\widehat{MSAY}$	$\hat{f}_{opt}$	MSQ
	Model using fishing effort in days fished				
Years		*MT/day*	*10^3 MT*	*10^3 DAYS*	
2	2.24	0.825	35.385	42.900	0.1351
3	1.62	0.791	33.072	41.801	0.0613
4	0.61	0.584	33.473	57.291	0.1210
	Model using fishing effort in hooks fished				
$\bar{T}_i$	$\hat{m}$	$\widehat{CPUE}_{opt}$	$\widehat{MSAY}$	$\hat{f}_{opt}$	MSQ
Years		*MT/10^3 hooks*	*10^3MT*	*10^6 hooks*	
2	0.64	0.477	35.913	75.279	0.1588
3	0.25	0.325	34.665	106.761	0.0769
4	0.15	0.262	33.719	128.512	0.1351

sustainable "average" yields (SAY) from the above solution and finding the maximum of this curve produces an estimate of MSAY. The SAY curve may not appear to be the best possible fit to the observed yield/effort data because the curve represents equilibrium yield whereas the observed values represent transient yields (Fig. 11). In addition, the SAY/total effective effort curve is derived from the actual least squares solution of the production model. The other parameters are defined as follows: m describes the symmetry of the curve between SAY and fishing effort and the concavity of the curve between CPUE and effort, for example when $m = 0.0$, the SAY curve is asymptotic and the CPUE curve is markedly concave upwards, when $m \rightarrow 1$, the SAY curve is skewed (Gompertz model) and the CPUE curve is slightly concave upwards, and when $m = 2.0$, the SAY curve is symmetric (logistic or Schaefer model) and the CPUE curve is a straight line; and $CPUE_{opt}$ and f_{opt} are estimates of the index of population abundance in metric tons per unit effort and the amount of total effective fishing effort expended at the point of estimated MSAY.

Since no age or size group composition studies have been performed on the South Pacific albacore population, averaging times for the equilibrium approximation technique were based on the number of age groups present in the Japanese longline fishery for albacore in the North Pacific. Otsu and Uchida (1963) recognized six age groups, ages 2 to 7, in the North Pacific fishery with age group 2 comprising a small proportion of the catch; hence a year-class contributed significantly to the catch for approximately 5 years. Using this information, an averaging time ($\bar{T}_i$) of 2 or 3 years for Gulland's approximation seemed appropriate for the South Pacific fishery. For comparative purposes, an averaging time of 4 years was also included.

Results of the production model analysis are presented in Table 2 and Figure 11. On the basis of mean sum of squares (Table 2), an averaging time of 3 years resulted in the best fit with an averaging time of 4 years being second best for fishing effort in both days and hooks. From the distribution of the observed data points (averaged) relative to the fitted values (Figure 11), it is obvious that the generalized production model using $\bar{T}_i = 3$ years can be used for predictive purposes within the range of the observed fishing effort.

Since the production models for effort in both days and hooks fished indicated a MSAY of 33,000-35,000 metric tons, the major differences between the models was in the estimation of $CPUE_{opt}$ and f_{opt} and in the shape of the SAY and CPUE curves. It must be remembered that both $CPUE_{opt}$ and $\hat{f}_{opt}$ are in terms of the fleet based in American Samoa; therefore, the $CPUE_{opt}$ and f_{opt} estimates refer only to vessels fishing for albacore in the same manner as the Samoan fleet. In particular, the total amount of fishing effort expended in the South Pacific will be considerably in excess of the values used or predicted in this analysis because much of the fishing effort is directed towards yellowfin, bigeye, and southern bluefin tunas. If this were a management situation, $\hat{f}_{opt}$ would have to be partitioned and adjusted for each segment of the South Pacific longline fishery.

DISCUSSION

Based on the generalized production models given in Table 2 and Figure 11, it must be concluded that the South Pacific albacore fishery has reached or nearly reached the level of MSAY, given the current constitution of the fishery. Any further increase in fishing effort, deployed in the same manner as the present fishing effort, will result in a further decline in CPUE, without any significant increase in yield and probably a decrease. If the South Pacific fishing fleet were to change its fishing strategy, for example by harvesting different age groups at different intensities or possibly by fishing for adult fish at greater depths in the middle South Pacific latitudes, the estimated MSAY for the stock might change.

Because the shape of the SAY curve was different for the two models presented in this paper as well as for models not reported on here that used a slightly different estimate of total catch and different measures of CPUE, I do not have a great deal of confidence in the shape of the right-hand limb of the SAY curve. With the above statement in mind and using the two production models presented here, if a 25 percent increase in fishing effort over the 1971 level is hypothesized, the estimates of SAY would decrease to 27,900 metric tons (CPUE = 0.57 metric ton/day) from a 1971 SAY level of 30,800 metric tons for the model using effort in days fished, or increase to 34,300 metric tons (CPUE = 0.44 metric ton/10^3 hooks) from a 1971 SAY of about 34,000 metric tons for the model using effort in hooks fished. Based on this analysis, the SAY cannot be increased appreciably and might decline significantly with a 25 percent increase in effort.

While a number of assumptions regarding the use of the generalized production model and the handling of the catch and effort data have been made, none of these assumptions are regarded as being unreasonable. Nor would slight departures from any of the assumptions invalidate the results from this "first cut" analysis. If the biological information were available to verify the assumptions or to make adjustments to the data as called for, sufficient data would be present to apply a more sophisticated approach.

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MFR PAPER 1128

Tires have no harmful effects on black sea bass and pinfish.

Experiments on Some Possible Effects of Tire Reefs on Pinfish (*Lagodon rhomboides*) and Black Sea Bass (*Centropristis striata*)

R. B. STONE, L. C. COSTON,
D. E. HOSS, and F. A. CROSS

Figure 1.—The surface area of a tire unit provides shelter for fishes and effective substrate for attachment of encrusting organisms.

ABSTRACT—A simulated tire reef was constructed in a 2,000-liter circular fiberglass tank to determine if pollutants would leach from the tires and affect pinfish (Lagodon rhomboides) *or black sea bass* (Centropristis striata), *two fishes commonly associated with artificial reefs on the Atlantic and Gulf Coasts of the United States. Periodic samples of these fishes from both control and experimental tanks showed no significant increase in concentrations of zinc, organochlorine insecticides, or polychlorinated biphenyls (PCB's) in either pinfish or black sea bass.*

INTRODUCTION

Natural, rough-bottom fishing grounds nearshore are scarce off the Atlantic Coast of the United States and in the Gulf of Mexico. Anglers often go 15-40 miles offshore to find extensive areas of rough bottom and the associated reef fishes. Because of the scarcity of natural reefs close to shore, many coastal states are actively building artificial reefs close to fisherman access points (Table 1). Tires are one of the most popular construction materials (Stone, Buchanan, and Steimle, 1974), since they are readily available at no cost, last indefinitely, are inexpensive to assemble into effective units, and provide a good substrate for fishes and encrusting organisms (Fig. 1). Off the east coast of the United States alone there are over 100 artificial reefs, many of which are constructed of scrap tire units[1].

As the number of tire reefs has increased, some people have asked if toxic materials in tires would leach into the surrounding waters and harm fishes using these reefs. It is a valid question that we thought should be answered, although we have observed no evidence of fishes being harmed during our field studies on experimental tire reefs. Prominently mentioned pollutants are zinc, reported to be a major contaminant in rubber (Malmström, 1956), and polychlorinated biphenyls (PCB's). Both a literature search and direct communication with tire company scientists[2] indicate PCB's are not used in manufacturing tires. There is the possibility, however, that tires could become contaminated with pollutants, such as PCB's, zinc, or organochlorine pesticides, either while in use or after being discarded. In previous experiments Nozaka, Nogao, and Kikuchi (1973) found no harmful substances leached from a cut sample of used tire soaked in fresh water, but we could find no information on the possible leaching of toxic substances from tires in salt water. To supply some answers to the question of whether tire reefs harm fish,

[1]Stone, R. B. A brief history of artificial reef activities in the United States. Proc. Artificial Reef Conf., Center for Marine Res., Texas A&M Univ., College Station, TX 77843. In Press.

[2]C. F. Winors, Goodyear Tire and Rubber Company, Research Division, Akron, Ohio, Pers. commun.

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Table 1.—Location of east coast artificial reefs that are constructed partially or completely of scrap tire units, March 1974.

Location	No. of tires
Ipswich Bay, Mass.	1,000
Shinnecock Bay, N.Y.	1,000
Ocean off Shinnecock, N.Y.	6,000
Ocean off Moriches, N.Y.	600
Great South Bay, N.Y.	3,500
Ocean off Fire Island, N.Y.	1,500
Ocean off Atlantic Beach, N.Y.	30,420
Ocean off Rockaway, N.Y.	6,500
Ocean off Monmouth Beach, N.J.	1,500
Ocean off Sea Girt, N.J.	80,000
Ocean off Indian River Inlet, Del.	2,000
Ocean off Ocean City, Md.	1,000
Bay near Millers I., Md.	660
Bay near Love Pt., Md.	660
Bay near Cedarhurst, Md.	660
Bay near Eastern Bay, Md.	660
Bay near Holland Pt., Md.	660
Bay near Patuxent, Md.	660
Tangier Sound, Md.	660
Ocean off Paramore I., Va.	2,500
Bay near Onancock, Va.	1,000
Ocean near Chesapeake Light Tower, Va.	300
Ocean off Morehead City, N.C.	1,000
Ocean off Wrightsville Beach, N.C.	500
Ocean off Lockwoods Folly, N.C.	3,800
Ocean off Murrells Inlet, S.C.	6,000
Ocean off Murrells Inlet, S.C.	36,000
Ocean near Charleston, S.C.	23,000
Ocean off Beaufort, S.C.	8,000
Ocean off Beaufort, S.C.	30,000
Ocean off Beaufort, S.C.	20,000
Ocean off Warsaw I., Ga.	40,000
Ocean off St. Simons, Ga.	24,768
Ocean off Brunswick, Ga.	25,536
Ocean off Cumberland I., Ga.	14,320
Ocean off Jacksonville, Fla.	7,000
Ocean off St. Augustine, Fla.	2,000
Ocean off Ponce de Leon Inlet, Fla.	1,500
Ocean near Cape Canaveral, Fla.	1,200
Ocean off Singer Island, Fla.	2,000
Ocean off Ft. Lauderdale, Fla.	300,000
Ocean off Hallandale, Fla.	1,000
Ocean off Elliott Key, Fla.	560
Total	691,624

we exposed two species of common reef fishes to the effects of tires in laboratory experiments.

EXPERIMENTAL PROCEDURE

We chose pinfish (*Lagodon rhomboides*) and black sea bass (*Centropristis striata*), since both species are known to inhabit tire reefs (Stone, Buchanan, and Parker, 1973). The fish were trapped near the laboratory and held in large tanks until used.

For the experiments, six used automobile tires were placed in a 2,000-liter circular fiberglass tank to simulate an artificial reef. A second identical tank without tires served as a control. Sea water entered at a rate of 15 liter/min after passing through an oyster shell filter.

Fish in both tanks were fed a mixture of dry commercial fish food and cut fish during the experiments. Salinity, temperature, and water flow rate were measured daily. Although we removed excess food and fecal material with a suction pump at least three times a week, some material did accumulate inside the tires.

In the first experiment, we analyzed 10 fish of each species for zinc, organochlorine pesticides, and PCB's and then weighed and placed 40 pinfish and 40 black sea bass in each tank. Samples of 10 pinfish were removed for analysis after 21 and 101 days and samples of 10 sea bass after 21 and 29 days.

In a second experiment using only sea bass, we duplicated the same experimental conditions except for cutting more holes in the tires to allow increased water circulation and thereby reduce the accumulation of organic material inside the tires.

In the pinfish-black sea bass experiment, we measured survival and concentrations of zinc, PCB's, and organochlorine pesticides in tissues. In the black sea bass experiment, only survival was documented. Metal concentrations were measured in muscle and liver tissue at our laboratory by atomic adsorption spectrophotometry. PCB's and pesticide levels were analyzed by gas chromatography at the Environmental Protection Agency Laboratory, Gulf Breeze, Fla. When we took samples of pinfish and black sea bass on day 21 to determine if there had been any accumulation of these pollutants, we had to remove the tires from the experimental reef tank since both the bass and the pinfish used them for cover. After removing 10 fish of each species from each tank we replaced the tires in the reef tank.

RESULTS

No mortalities occurred during the first 21 days of the pinfish-black sea bass experiment in either the control or experimental reef tank. But on the 22nd day, after the fish had been returned to the reef tank and the tires replaced, there was a definite change in their behavior. The bass, which normally utilized tire reefs for shelter, began swimming or lying around the edges of the tank near the surface of the water and the pinfish began to actively defend territories in and around the tires. Soon after this change in behavior the bass in the reef tank began to die and within 7 days after sampling, 16 had died. On the 29th day of the experiment, we again removed 10 black sea bass, but no pinfish, from the control and experimental tanks. The remaining bass in the reef tank died within the next week, but all the pinfish in both tanks were alive when the experiment was ended after 101 days.

Table 2.—Analysis of total fish for DDE, DDD, DDT, PCB, and Dieldrin (values of all compounds "not greater than").

Species	Day	Condition	DDE	DDD	DDT	PCB	Dieldrin
					µg/g wet wt.		
Pinfish	0		0.290	0.070	0.083	0.880	0.018
	21	With tires	.095	.061	.069	.420	.015
		Without tires	.130	.069	.060	.420	.019
	101	With tires	.100	.048	.074	.380	.010
		Without tires	.170	.060	.064	.730	.010
Black sea bass	0		0.032	0.039	0.030	0.190	0.011
	21	With tires	.034	.037	.037	.190	.012
		Without tires	.038	.039	.037	.240	.012
	29	With tires	.045	.041	.052	.230	.015
		Without tires	.043	.045	.045	.230	.011

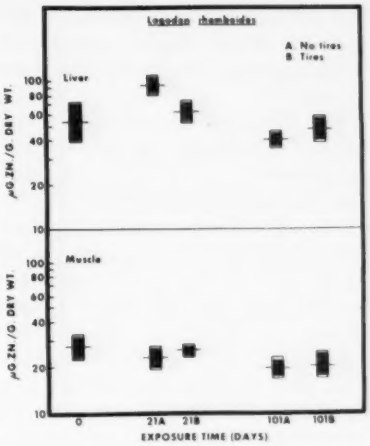

Figure 2.—Concentrations of zinc (µg/g dry weight) in muscle and liver of pinfish *(Lagodon rhomboides)* that were maintained in tanks with (B) and without (A) tires for periods of 21, and 101 days. The mean (horizontal line), ± standard deviation (clear areas) and ± 2 standard errors of the mean (solid (black) areas) were computed on log-transformed values, and the antilogs are shown on the graph. Each set of values represents analysis of 5 individual fish.

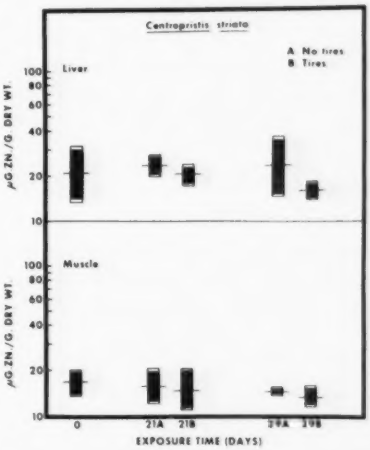

Figure 3.—Concentrations of zinc (µg/g dry weight) in muscle and liver of black sea bass (*Centropristis striata*) that were maintained in tanks with (B) and without (A) tires for periods of 21 and 29 days. The mean (horizontal line), ± one standard deviation (clear areas) and ± 2 standard errors of the mean (solid (black) areas) were computed on log-transformed values, and the antilogs are shown on the graph. Each set of values represents analysis of 5 individual fish.

There were no differences in the levels of PCB's and organochlorine insecticides in the tissues of fish sampled before and during the first experiment (Table 2), for either species. Neither were there any significant differences in the relative levels of pollutants in fish exposed to tires

and fish not exposed. Before the experiment began, pinfish had higher concentrations of both pollutants than sea bass.

For both species, zinc did not increase significantly above the pre-experiment levels in muscle and in liver for black sea bass (Fig. 2 and 3). There was some increase in the zinc levels in livers of pinfish at the end of 21 days, but it was higher in the fish not exposed than in those exposed to tires; at the end of 101 days the level was lower than the pre-experiment level for both those exposed and those not exposed.

Significant quantities of zinc, at least in chemical form that was readily available to the fish, did not leach from the tires during the experiment. We made one analysis of the water for zinc 31 days after the start of the experiment and found no significant difference in the zinc content of the water in the two tanks: control tank 1.7 μgZn/liter, and reef tank 1.3 μgZn/liter.

The only mortalities in the black sea bass experiment occurred when 6 fish jumped out of the control tank and 1 jumped out of the experimental tank after being startled by lights turned on at night.

DISCUSSION AND CONCLUSION

There is no apparent relation between tires and concentrations of organochlorine insecticides, PCB's, or zinc in either black sea bass or pinfish. We found no change with time in the levels of PCB's, organochloride insecticides, or zinc between control and experimental fish exposed to a tire reef. Of the two species of fish tested, black sea bass and pinfish, it appears that pinfish accumulate higher levels of PCB's and insecticides. This may reflect differences in habitat and feeding habits. From the absence of mortalities in the black sea bass experiment (with the exception of those that jumped out of the tanks), and the results of our tests for accumulations of pollutants in the fishes, we concluded that the death of the bass in the pinfish-black sea bass experiment was due to the handling received during the first sampling (day 21), changes in behavior caused by competition for the limited habitat provided by the tires, or dietary deficiencies. Also, fecal material and unused food that accumulated within the tires may have washed out during the sampling (day 21) and contributed to the deaths. This problem was eliminated in the black sea bass experiment since the holes we cut in the tires resulted in better water circulation and less debris accumulation.

Since tires have no detrimental effects on pinfish and black sea bass and field studies of tire reefs demonstrate their potential to increase coastal fishery resources, improve catches in local sport fisheries, and beneficially affect the economics of local communities, (Stone, Buchanan, and Parker 1973), we consider tires suitable material for reef construction in many situations.

ACKNOWLEDGMENTS

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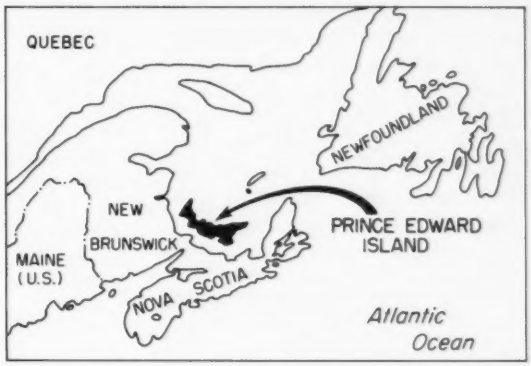
MFR PAPER 1129

Transplanting oysters to good quality barren ground can increase their number and quality.



Development of a Program to Rehabilitate the Oyster Industry of Prince Edward Island

CLYDE L. MacKENZIE, JR.

ABSTRACT—The author developed and implemented an oyster industry rehabilitation program for Prince Edward Island in which large vessels are to transplant oysters from unharvested stocks and shells from buried deposits and spread them over otherwise barren public grounds. Great biological and ecological potentials exist for increasing oyster production because of: (1) regular annual spat-fall (reproduction), (2) high survival rates of oysters, (3) adequate growth rates, (4) existence of more than 200,000 boxes of unharvested stocks of small oysters in either deep water or on poor grounds as well as several million bushels of oyster shells, and (5) availability of at least 1,000 acres of otherwise barren public grounds possessing ecological features that produce high-quality oysters. After a few years, oyster production should more than double; earnings of the 200 public fishermen should rise steadily from an annual average of $2,300 to $4,550; and earnings of other industry sectors should also rise. The ratio of program costs to monetary benefits for the fishermen should eventually exceed 1 to 20.

INTRODUCTION

Prince Edward Island (P.E.I.), Canada, lies near the northern end of the range of the American oyster (*Crassostrea virginica* Gmelin), which extends from northern New Brunswick southward along the Eastern and Gulf Coasts of the United States to Mexico and also the West Indies (Galtsoff, 1964). In spite of the northern latitude, the environment on the Island is excellent for oysters, partly because estuarine water temperatures range from 70° to 75°F during the summer. The oyster industry has been an important part of the Island's tradition and economy since the mid-1800's. In recent years, however, annual production of oysters has been 20,000 to 30,000 boxes[1] (25,000 to 37,500 bushels), about one-third the peak years of 1880 to 1900, and the trend is downward (Fig. 1). This harvest has an annual value of about $400,000 (Morse, 1971). Virtually all oysters are exported from the Island to be sold in the cities of eastern Canada, where they are eaten raw on the half shell.

Oysters are harvested from both public and leased grounds, but most from the former during two seasons. About 200 men and women are engaged in the public fishery. Harvesting from public grounds and most leases is by means of tongs from dories. The oyster industry is labor-intensive and of low productivity and earnings; capital inputs and expenses are high in relation to earnings.

After 1890, the decline in oyster production seems to have been mainly the result of: harvesting oysters of all age groups until the early 1900's; an increasingly degraded habitat caused by silting from land erosion; and a disease that killed most stocks between 1915 and 1954. Virtually no effort has been made on public or leased grounds to increase the quantity or quality of oysters by such measures as spreading cultch shells, transplanting oyster stocks, or reducing mortalities.

Oyster beds in P.E.I. were discovered in most estuaries in the mid-1800's, and an oyster fishery developed as the human population and consequently the demand for food rose. The oysters were harvested with tongs from fishing dories. Since most oysters were shipped off the Island, the oyster industry was important as a means of employment. Production reached 70,000 boxes in 1890, the peak year. Eventually, the virgin beds were fished down and production declined. The fishermen's practice of including small oysters attached to those of market size in the harvest was a significant cause of the decline (Needler, 1931). In the early 1900's, however, various regulations and policing required fishermen to return these to the grounds (Found, 1927). The development of agriculture and consequent severe erosion caused sediment deposition on oyster grounds (Kemp, 1916). Later construction of roads caused additional deposition (de Belle, 1971) which further degraded the environment for oysters and added to the decline.

A disease known as "Malpeque Disease" first struck the oysters of

[1]A P.E.I. "box" = 5 pecks or 1.25 U.S. standard bushels.

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Figure 1.—Oyster landings on Prince Edward Island, 1880 to 1972 (Morse, 1971).

remained nearly barren. Leased grounds do play an important role in oyster production, however, since all oysters harvested from contaminated public beds during the spring season are held on the uncontaminated leased grounds over summer before they are marketed. Termed relay oysters, they have amounted to about 60 percent of total production (about 12,000 boxes) in recent years. Most

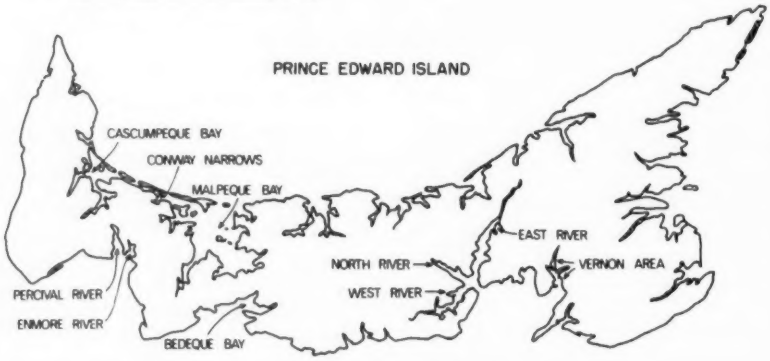

Figure 2.—Prince Edward Island showing estuaries where most oysters occur.

Malpeque Bay in 1915, and eventually killed nearly all oysters in the area. Gradually, this disease spread to other estuaries. It nearly destroyed the oyster industry since oysters suffered heavy mortalities (Needler, 1931, 1940, 1941; Needler and Logie, 1947; Logie, 1956; Found and Logie, 1957 Medcof, 1961; Drinnan and Medcof, 1961). A disease-resistant stock was propagated in some original areas until production rose again to reach a level of 30,000 boxes in 1950, but afterward it began to decline again. Presumably, the endemic oyster populations are now resistant to Malpeque Disease, since no outbreaks of disease have occurred since 1954.

A system of leasing grounds to individuals started about 1912 (Patton, 1913). The granting of a lease was intended to give an individual the right to protect the oysters he had either raised on the site or transplanted from public beds. Leased grounds averaged 4 acres. The areas granted for leasing had virtually no oysters on them, suggesting that the environment in those areas was unsuitable or marginal for oyster culture.

This leasing system has never worked well and most leased grounds have relays are held on the few larger leased grounds of from 8 to 20 acres.

P.E.I. has many estuaries, some of which penetrate deeply into its coastline (Fig. 2). Oyster beds varying in size from scattered individuals to extensive commercial-size stocks occur in most of these. The largest bed occurs along a 10-mile segment of the upper East River where some 132,000 boxes of oysters cover about 210 acres. (Most lie on grounds under water too deep for tonging.) The next largest beds occur in Bedeque Bay, where three beds hold a combined total of about 125,000 boxes of oysters and cover about 400 acres. All these oysters grow on grounds sufficiently shallow for harvesting, but their quality is poor. After these areas, the most significant beds occur in Cascumpeque Bay, northwest sections of Malpeque Bay, and West, North, Enmore-Percival, and Vernon Rivers. In all estuaries, oysters grow in clusters consisting of several age groups. Deposits of buried shells line the channels and banks of rivers and form reefs and cones that rise as high as 20 feet above bay bottoms. Such formations prove that extensive oyster beds once existed in most estuaries.

OBJECTIVES OF INVESTIGATION

A few years ago, the Provincial Department of Fisheries, P.E.I., charged me with developing, and if possible, implementing a management program to increase both production of oysters and earnings of the industry. My investigation lasted 12 months, from August 1972 to July 1973.

Except for literature references, the information presented in this report was gathered from direct observations and surveys, including scuba diving.

BIOLOGY OF OYSTERS

During this investigation, some biological features directly related to production were studied. They included: setting frequency, growth rates, and causes of mortality.

Setting Frequency

No previous records describing annual frequency of oyster setting on public or leased beds existed. The following direct procedure was used to determine reproductive frequency and estimate relative success: 1) make standard collections of oysters from various sites on beds; 2) determine the number in each age group; and 3) compare the total number of oysters among age groups. If the numbers of an age group within the total is relatively large, this reflects a good reproduction season. Spat counts on older oysters and shells were made in late fall because earlier counts are unreliable (some spat die after they set and others may be overlooked because of their small size).

During November 1972, this procedure was followed on beds in six estuaries that support oyster fishing. One of these was the bed in the deep channel of East River. Collections of oysters and shells were made by either scuba divers or with tongs. It was possible to identify five age groups of oysters on the basis of both annual shell growth rings and size. These were spat to 4-year-olds. Oysters that were 5 or more years old were counted with 4-year-olds. Accordingly, relative reproductive success was estimated from 1968 to 1972. The data showed that oysters set in commercial quanities

in these estuaries practically every year (Fig. 3). For example, in the two most important areas. Bedeque Bay and East River, the oyster set was successful in all 5 years, and in West River, there was poor reproduction of the 1972 class, but it was successful in all previous years.

Growth Rates

There were again no historical records available listing annual increments of oyster growth. I determined these by measuring the widths of growth bands on oysters from various beds after growth had ceased in November 1972. The average width of these bands from most beds, e.g., those in East River, was 0.75 inch. Accordingly, oysters became legal size, 3.0 inches, on most beds in 4 years after setting. In most sections of Bedeque Bay oyster beds, however, growth bands averaged about 1.5 inches wide, and in Conway Narrows and Malpeque Bay, they averaged only 0.4 inch wide.

Causes of Mortality

No previous studies of causes of oyster mortalities had been made on any beds, with the exception of those losses caused by Malpeque Disease.

Oyster beds in several estuaries were examined to detect causes of mortality from August to late November 1972. In monthly surveys divers examined oyster beds for potential predators and excessive sedimentation. Collections of oysters were then examined for extent of mortality from each cause. Because of ice cover, examinations were not made from December 1972 to April 1973 but were continued during May, June, and July 1973 to verify earlier estimates.

Oysters of P.E.I. have few natural enemies. The main causes of mortality are suffocation in silt, predation by starfish, ice, and extreme cold. Relatively few oysters are killed by oyster drills, mussels, or possibly, mud crabs.

Suffocation by silt kills oysters in the upper East River Channel, but not on most other grounds that are shallow because on the latter, wave action clears silt deposits. In East River and some other estuaries, silt washes off farm land and onto oyster beds lying in the channel bottom. The silt flood

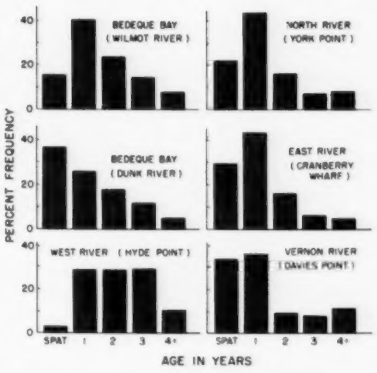

Figure 3.—Bar heights show relative numbers of oyster age groups collected randomly from six grounds, in fall 1972.

occurs during thaws in winter and in spring when temperatures range between about 32° and 40°F and the oysters are dormant. While dormant, oysters cannot clear silt deposits by pumping. Consequently, when temperatures rise and oyster metabolism increases, those covered by silt die. Usually the older oysters are at the bottom of clusters.

Starfish *(Asterias vulgaris)* do not occur within any major oyster beds, such as those in Bedeque Bay or East River. Nevertheless, scattered starfish destroy oysters along edges of beds there. They consume the smaller oysters in clusters (Needler, 1932). For example, in an isolated sample from Bedeque Bay, they destroyed 33 percent of the spat, and a few yearlings, but no older oysters.

Ice covers estuaries from mid-December to late April and kills oysters in shallow zones. Thickness varies from about 1 to 3 feet, depending on velocity of water currents and temperatures. At low tide, ice lies on the bottom in intertidal and shallow zones. Some oysters are forced into the bottom and killed. In rivers where currents are strong, no oysters lie along the shorelines since drifting ice scours these in spring.

In those years when air temperatures fall far below 0°F for several days before ice has formed in the fall, oysters are killed in intertidal zones. There is one record available of the frequency of oyster mortalities resulting from extreme cold. In Vernon River, intertidal oysters were killed three times in 20 years before 1972-73.

Oyster drills *(Urosalpinx cinerea)* are unimportant predators, since they occur in low densities and isolated patches. In Bedeque Bay, drills occur along the western edge of Wilmot River, but not in Dunk River. Where they were encountered, mortalities of oysters were about 2 percent; only spat and yearlings were killed.

Oysters smothered by dense growth of mussels *(Mytilus edulis)* were not found, but Medcof (1961) and fishermen report this has occurred in the past.

Fishermen cause most preharvest mortality. They kill many seed oysters in the cleaning process of knocking them from market-size oysters. This cause of mortality is unavoidable.

In sum, it has been established that oysters set regularly, and both grow and survive well on P.E.I. Morse (1971) was not accurate in stating, without presenting any evidence, that oysters fail to reproduce, i.e., they do not set frequently, nor grow and survive well.

ECOLOGY OF OYSTER GROUNDS

The distribution, abundance, availability, and quality of oysters in the commercial fishery on P.E.I. depend on several physical factors, especially the size of estuaries, bottom type, water depth, temperature, salinity, and the distribution and abundance of various animals and plants. Many ecological factors must be considered in developing a management program to enlarge and increase the number of oyster beds.

Physical Characteristics

The large size of P.E.I. estuaries is one of the most significant reasons that oyster populations thrive, since not only are oyster larvae easily detained during their period of development, but the shallow waters become warm during summer. The greatest length in miles for estuaries supporting significant oyster beds, including lengths of confluent rivers, is: East River, 17; Malpeque Bay, 13; Cascumpeque Bay, 7; West River, 7; North River, 6; Enmore River, 5; Vernon River, 5; and Bedeque Bay, 3.

The firmness of estuarine bottoms on P.E.I. varies widely. Oysters grow on sand, clay, shell deposits, and also mud that is barely firm enough to support them, although in many areas the soft bottom cannot support oysters. A significant factor that influences oyster quality, particularly shape of shell, is bottom hardness. Single oysters growing on hard bottoms have a round shape with a deep cup (fancy and choice grades), while oysters growing on soft bottoms tend to have a long and narrow shape (standard and commercial grades).

The estuaries are characterized by broad, flat grounds and narrow, deep channels. Oysters inhabit grounds that range from intertidal to a 35-foot-deep channel (East River). Most oysters grow on grounds that are covered by from 1 to 12 feet of water at low tide. The usual tidal range is from 2.5 to 6 feet.

In July and August, water temperatures in estuaries usually range from 70° and 75°F (Needler, 1931). Temperatures become that high because the rivers and bays have extensive shallow zones and broad intertidal flats which are a deep red color and absorb much radiant energy. These temperatures make it possible for oysters to reproduce regularly and grow well.

Water salinity is another basic factor affecting oyster abundance. In large sections of Bedeque Bay and East River, it is high enough to permit the growth of oysters, but sufficiently low (< 15 ppt) during the spring run-off period to exclude starfish, the only significant oyster predator.

Siltation of oyster beds appears to be a primary reason for the oyster production decline from 1890 to 1915 and its slow recovery during the disease-free period from 1955 to 1972. Deposits of silt not only suffocate oysters but also cover hard surfaces and thereby prevent setting of young oysters (MacKenzie, 1970). Quantities of silt flowed into the estuaries during the forest-cutting and shipbuilding period and farmland increased from 7 to 85 percent of the Island's area from 1830 to 1900 (Clark, 1959). The forests were cut and farmland was plowed to the banks of rivers and streams. Presently, run-off and consequent siltation are greatest during the thaw and rainy spring period. The rivers become a brick red color when waters become heavily laden with silt and long tongues of red water extend into blue-green water at their mouths. The construction of causeways across some rivers in the 1950's resulted in reduced flow rates and also increased the siltation rate. Deposits of silt were observed overlying shell deposits in several estuaries. For example, in parts of Bedeque Bay, East River, and Vernon River, shell deposits were covered by silt as thick as 2 feet. Presumably, the silt accumulated during the past 30 to 40 years following oyster mortalities caused by Malpeque Disease.

Associated Fauna and Flora

Starfish are the most serious oyster predators. They inhabit sections of most estuaries, and appear to limit the distribution of oysters in some. Oyster beds that occur in the upper reaches of estuaries where salinities become low are essentially free of starfish and other predators, but starfish do occur, especially in channels, in higher salinity zones.

Two phases of starfish biology were studied at the Biological Laboratory, Fisheries Research Board of Canada, on Bideford River, at Ellerslie. To develop a management program for oysters, there was a need for information on rates of oyster predation by starfish, and on the minimal salinity tolerance of starfish. We needed to know the maximum starfish density allowable for survival of most seed oysters spread over otherwise barren ground, and if absence of starfish is a result of periodic low salinities.

Data on starfish feeding rates were obtained from laboratory and field cage studies. In the laboratory, starfish 3.0 inches in diameter were held in running water pans with an ample supply of oysters 1.0 inch in diameter. Because of time limits only two water temperatures were tested. In 7 days, individual starfish consumed an average of 9.4 oysters (1.3/day) at 40°F, and 17.0 oysters (2.4/day) at 50°F. In field cages suspended in water (32°F) under the ice, individual starfish consumed about three oysters in 7 days (0.4/day). These laboratory and cage feeding studies establish that starfish can consume small oysters rapidly and that some predation occurs in winter. Significant mortalities of seed oysters would take place where densities of adult starfish exceeded about 1 individual per 10 square yards.

The salinity death point of adult starfish was determined by holding individuals at a series of constant salinities for 39 days. Starfish held in water at 14 ppt and below, and 1 of 2 starfish held at 16 ppt, died, while those held in water at higher salinities survived. Relating this to oyster management, starfish cannot inhabit grounds where water salinities fall below 15 ppt but they can inhabit those which remain above this point, if other environmental factors are favorable.

Adult starfish do not generally inhabit grounds less than 4 feet deep at low water. Probably, fresh water flowing under the ice during winter ebb tides kills them.

The tube worm *(Polydora websteri)* grows abundantly on oysters in certain areas. I found that it plays an important role in oyster harvesting. It forms a weak bond between oysters in clusters. A cover of tube worms prevents oysters from cementing themselves to adjacent oysters as they grow (Fig. 4). Not only can fishermen clean market-size oysters faster, but also the under-size oysters are separated into smaller clusters when returned to the bottom and grow into a better shape or grade. Also, fishermen kill fewer seed oysters in cleaning market-size oysters. Tube worms are abundant along the western edges of oyster beds in Bedeque Bay and on most beds in East River, but are scarce in other sections. Tube worms do not tend to burrow holes in live oyster shells, and accordingly market oysters do not have mud blisters which reduce their aesthetic appeal.

Various animals, such as boring sponges *(Cliona* sp.) (Needler, 1941; Worburten, 1958; Medcof, 1961); flatworms *(Stylochus* sp.), calcareous bryozoans *(Electra crustulenta);* oyster drills *(U. cinerea)* (Medcof, 1961; Medcof and Thomas, 1969); slipper limpets *(Crepidula fornicata, Crepidula plana)* (Needler, 1941); mussels *(M. edulis)* (Needler, 1932, 1941; Medcof,

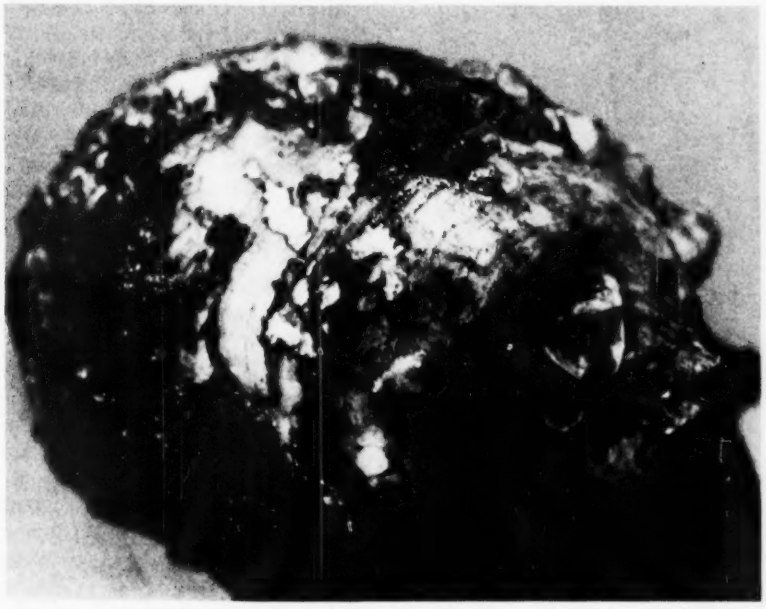

Figure 4.—A market-size oyster from Bedeque Bay. This oyster was easy to clean because numerous attached worm tubes (dark zone in center of oyster) weakened the bond between adjoining oysters.

1961); barnacles (species not determined); and mud crabs *(Neopanope texana)* (Needler, 1941; Medcof, 1961) inhabit oyster beds, but the impact of each on the oyster fishery is small.

Two types of plants have some impact. Sea lettuce *(Ulva lactuca)* thrives in Wilmot River where solid patches of it cover most oysters and hinder harvesting. Eelgrass *(Zostera marina)* is generally beneficial as its roots stabilize the bottom; its short and sparse leaves do not interfere with oyster harvesting (Medcof, 1961).

Characteristics of Bedeque Bay and East River

Bedeque Bay and East River produce about 83 percent of the Island's oysters and are where the pilot projects later described were conducted. Oysters at the heads of these two estuaries are of poor quality, but they improve towards the mouths. Needler (1932) believed this to be generally true for oysters in all estuaries of P.E.I.

Bedeque Bay is fed by two rivers, Wilmot and Dunk, both of which contain large oyster beds (Fig. 5). A single bed occurs between Hilson Point and Wilmot Point and extends toward a highway bridge crossing Wilmot River, where an estimated 25,000 boxes of oysters grow on about 100 acres of ground. Three beds occur between Hurd Point, Oyster Point, and Murray Island in Dunk River, where an estimated 100,000 boxes of oysters grow on about 300 acres of ground. Most of these oysters are not harvested because they are of poor quality.

Reproduction and growth of oysters are excellent. Oysters set over the entire extent of the oysters beds practically every year. During the setting season, from one to three spat are caught on virtually all oysters. Oysters grow about 1.5 inches per year. This regular annual setting and rapid growth result in the formation of clusters that may consist of 100 or more individuals of several age groups. Even before the oysters attain a size of about 3 inches, they grow only in length owing to lateral crowding. Consequently, most market-size oysters are long and narrow and are graded commercial. The moderate quality oysters, choice and standard grades, grow along the western edges of the beds, where harvesting takes place.

About 600 acres of grounds possessing excellent environmental conditions for oysters are available for expanding these oyster beds westward: 100 acres in Wilmot River and 500 acres in Dunk River. The grounds are protected from storms by land relief. Water depths of from 3 to 4 feet at low tide prevent ice and cold from killing the oysters yet allow easy harvesting. Starfish do not generally occupy these grounds. Young-of-the-year starfish inhabiting them during the summer of 1972 were absent the following spring, probably killed by fresh water flowing under the ice during winter ebb tides. A tube worm cover on oysters would work to the advantage of oystermen by speeding up harvesting rates and improving the average grade. Some ecological features of the bay are summarized in Table 1.

The East River is 17 miles long. During this investigation, a virgin oyster bed was discovered growing in the channel along a 10-mile section in the upper river (Fig. 6). An inventory showed that the bed covers 210 acres and consists of about 132,000 boxes of oysters (283,000,000 individuals). An estimated 106,000 boxes of oysters covering 140 acres in a band from 400 to 600 feet wide lie under water too deep for harvesting. Some oysters within the upper part of the zone are too poor in quality for harvesting. A shell deposit ranging from several inches to 5 feet thick underlies the entire bed.

Regular annual oyster setting results in clusters containing at least five age groups. In the deep beds the smallest oysters are well shaped, but

Table 1.—Comparison of features between virgin oyster beds and barren grounds in Bedeque Bay and East River.

Bottom type	Bedeque Bay		East River	
	Virgin bed (firm)	Barren ground (firm)	Virgin bed (firm)	Barren ground (firm)
Depth at low water (feet)	1-2	3-4	10-35	3-10
Salinity (ppt)[1]	4.1-14.1	22.6-22.7	6.9-15.6	18.0-22.3
Reproduction	annual	annual	annual	probably annual
Starfish	absent	few juveniles	absent	few
Tube worms	few	many	many	many
Annual growth (inches)	1.5	1	0.75	0.75

[1]Determined at low water, late May 1972

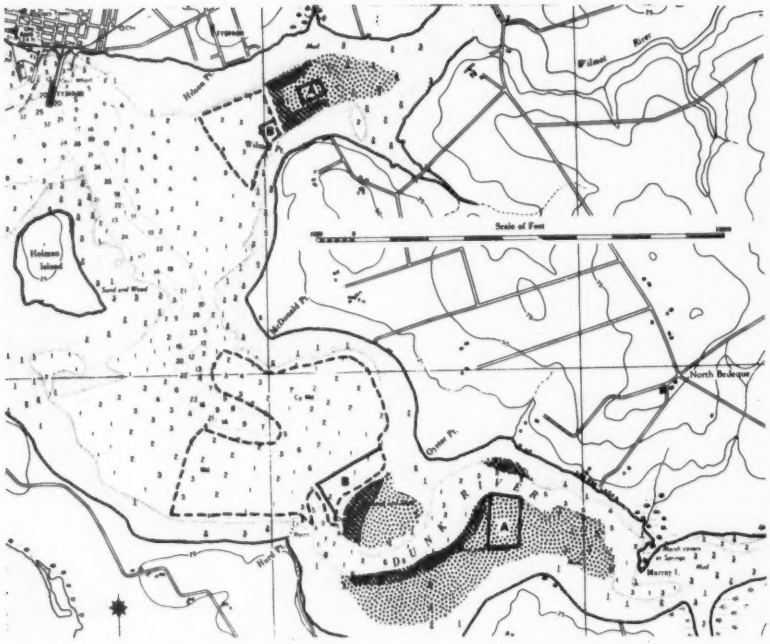

Figure 5.—Chart of Bedeque Bay showing general areas of oyster population (dotted) and oyster harvesting (lined). In 1973 oysters were transplanted from A to B sections. Barren areas outlined by broken lines produce oysters of high market value. Depths are shown at lowest normal tides. Usual low tides are about 1 foot deeper than indicated.

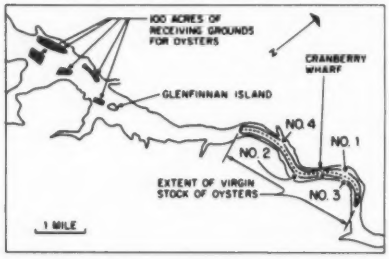

Figure 6.—Portion of East River showing the locations of 140 acres of virgin oyster bed (divided into four sections for management purposes), and 100 acres of otherwise barren grounds that can produce oysters of high value, within the designated fall fishing section.

most oysters over 3 inches are long and narrow due to overcrowding.

About 100 acres of grounds within the uncontaminated section and several hundred acres below it in the contaminated section, possessing excellent environmental conditions for oysters, are available for establishing new beds. The grounds are well protected from storms by land relief and the water is 3 to 10 feet deep at low tide, offering protection from ice and cold. Starfish cannot generally inhabit the shallow grounds (<4 feet) but they might invade the deeper ones. If starfish become numerous on a bed and kill the small oysters before they can be controlled, the ground might require periodic replenishment by transplants from the upriver virgin bed. It is anticipated that worm tubes will cover oysters.

The contaminated grounds in the lower river were not thoroughly studied, but they appear to have about the same environmental features for oysters as those immediately below Glenfinnan Island. Some river features are included in Table 1.

Characteristics of Leased Grounds

An examination was made of the environment of some typical leased grounds to determine their suitability for cultivating oysters. Leases had been granted in areas barren of oysters. The examination revealed that these grounds had more than one of the following undesirable conditions: Intertidal, soft bottom, infrequent setting of young oysters, slow growth, or many starfish. Because of these poor environmental conditions, it would be virtually impossible to grow seed oysters to market size on them as a profitable enterprise.

Morse (1971) and others have recommended that industry management be oriented towards cultivating oysters on leased grounds, with a deemphasis of the public fishery. They probably did not consider the poor environment of these grounds as well as some other negative features (see below) for cultivating oysters by individual fishermen.

Impact of Domestic Pollution

Over half the areas where public oyster beds occur are contaminated by domestic pollution. As a consequence, the Federal Government has closed them for the direct marketing of oysters for human consumption. Nevertheless, oysters can be harvested for relaying onto leased grounds which are in uncontaminated waters. Oysters from uncontaminated beds can be harvested directly for market. The contaminated areas include the entire extent of Bedeque Bay, part of West River, both the north and south parts of East River, North River, and other smaller areas. The uncontaminated areas include most of West River, the middle part of East River, and some smaller areas.

FUNCTIONAL OPERATIONS OF INDUSTRY

The oyster industry on P.E.I., including the public fishery and the buying and handling of relay oysters, is labor-intensive, with low productivity and earnings. Capital inputs and expenses are high in relation to earnings. This industry is traditional in the sense that few changes have been made since it began in the 1800's. The oyster fishermen and buyers function efficiently because they make maximum use of the equipment and resources available; little money, labor, and time are wasted. As individuals, the fishermen value their independence and enjoy their work when earnings are adequate. Besides oystering, some also fish for lobsters and smelts and some farm.

The Public Fishery

About 90 percent of the oysters are harvested from public beds; approximately 60 percent are from beds contaminated by pollution during the

spring oyster season, which extends from 1 May to 15 July. Most spring beds are in Bedeque Bay, but some are in parts of East River, North River, and elsewhere. Oysters harvested from contaminated beds are relaid onto leased grounds in clean waters where they cleanse themselves, and they are sold during the fall marketing season that begins in September and ends in early winter. The remaining 40 percent are harvested from public beds free of pollution during the fall oyster season, which extends from 1 October to 30 November. Most beds are in West and East Rivers. Fall production from West River has averaged about 1,600 boxes, and from East River about 3,200 boxes per season. The final 10 percent of oysters harvested originate from natural reproduction and growth on leased grounds.

Bedeque Bay and the East River produce 83 percent of P.E.I.'s oysters. About 50 percent of the oyster harvest, or 9,000 boxes, is from Bedeque Bay, and about 33 percent or 6,000 boxes, is from East River.

Usually, there are about 200 public fishermen, but when the economy is depressed, this number increases. Most live in Prince County in the western part of the Island, a considerable distance from the oyster grounds. For example, the average traveling distance for most fishermen to Bedeque Bay is about 35 miles, and to West and East River, about 90 miles. Rather than commuting daily, the fishermen live at the shore in one- or two-man trailers during the week[2] (Fig. 7); they deliver their oysters to buyers and return home on weekends.

The public fishermen are highly mobile. They move their dories and trailers from one oyster-producing estuary to another without losing harvesting time. The dories are trucked and the trailers towed. When fishermen get word of good oyster fishing on grounds in either New Brunswick or Cape Breton, a few may even travel there to harvest oysters for a short period.

Figure 7.—A fisherman's settlement along East River, showing a permanent building where oysters are graded and packed, and trailers in which fishermen live.

All public fishermen use similar equipment to harvest oysters, including a dory about 14 feet long, fitted with a 6- × 18-inch tonging board on which oysters are cleaned at the bow. Usually the boat is powered by an 18 or 20 horsepower outboard motor and has an anchor and dory cable. Most fishermen use two pairs of tongs with 8- or 10-foot handles in Bedeque Bay and three pairs with 8-, 10-, and 12-foot handles in the fall fishing areas, where the water is deeper. Sometimes even longer handles are used. Fishermen also carry three or four oyster boxes in their dories. They wear boots, oilcloths, and rubber gloves, besides their underclothing. At low tide fishermen harvest oysters with tongs from dories (Fig. 8). An average of three marketable oysters are tonged up every four dips, but this number ranges from zero to 10 and higher.

The harvest rate per day averages two boxes in the spring season, and one and one-half at the beginning and one at the end of the fall season. The harvest rate per hour is the same at the beginning of the fall season as it is during the spring season, but the fishermen do not work as long because of the shorter daylight period.

Another means of harvesting is by picking along the shore at low tide. This is done either by hand or by using a short-handled rake with about five small tines.

In Bedeque Bay, fishermen find the good quality oysters (fancy and choice grades) are too sparsely scattered along the western edges of oyster beds; the moderate quality oysters (choice and standard grades) grow on only about 35 acres of the beds; and poor quality oysters (commercial grade) in large, difficult-to-separate clusters grow on the majority of the beds. The average fisherman harvests about 10 boxes of oysters per week, a rate that remains constant, except for a slight dip in June, during the entire 10-week season (Fig. 9).

Figure 8.—Most oysters are harvested from shallow grounds by fishermen using tongs from a dory.

In East River, in the section open for fall fishing, public fishermen find that oysters grow on only about 20 acres of ground. The grade of oysters averages about half standard, half choice. The average fisherman harvests eight boxes of oysters during the first week of the season and this gradually falls off to about six boxes near the season's end. Since about 100 fishermen begin the fall season in that river, however, the bulk of market-size oysters are harvested off these grounds within the first 2-3 weeks of the 9-week season (Fig. 10, 11).

During a season, public fishermen harvest about half the market-size oysters that grow on a bed (Resource

[2]All fishermen cook their own meals in their trailers. Usually, meals are of low quality as they are often hastily prepared, high in starch, and low in protein and green vegetables. Trailers have no refrigeration; this limits the variety of food that can be prepared. When the tide is low during mid-day, fishermen eat a light lunch in their dory.

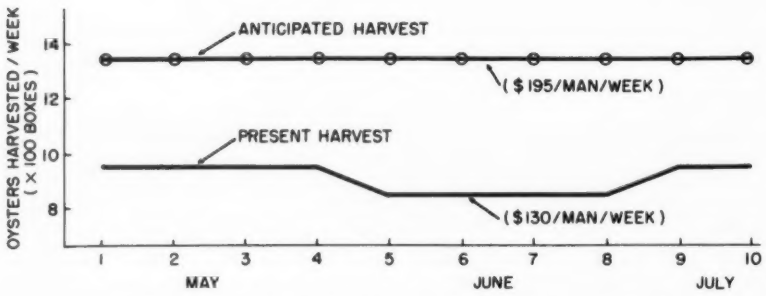

Figure 9.—Present and possible harvest yields of oysters during season in Bedeque Bay. The anticipated yield is that expected after recommended management program is conducted.

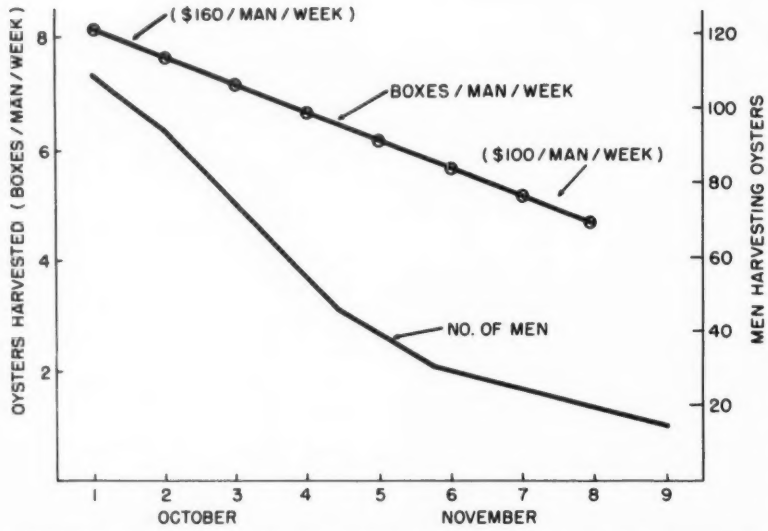

Figure 10.—Present harvest yields of oysters and number of fishermen during season in East River.

Development Branch, Fisheries Service, Environment Canada, pers. commun.). Oyster beds are self-perpetuating, i.e., a new crop of young oysters sets on them regularly to replace the market-size oysters harvested. Oysters have been harvested annually from the same beds for many years.

The public fisherman stores his oysters on the shore and usually sells them to a buyer on the weekend. Some fishermen have their own leased grounds and spread their harvest of relay oysters on them, rather than sell directly to buyers. Usually, fishermen harvest and sell these when oysters become scarce on the fall public beds.

Strict laws regulate oyster harvests by public fishermen. The most significant are: the only devices permitted on public grounds are hand tongs and picks; minimum marketable size limit is 3 inches across the longest part of the shell; harvesting from public grounds is allowable from 1 May to 15 July in areas contaminated by domestic pollution (with all oysters relayed on leased ground in uncontaminated areas) and from 1 October to 30 November in uncontaminated areas.

Oyster Buyers

About 10 buyers purchase oysters from public fishermen during the spring and fall seasons. In spring, the oyster buyers shovel relay oysters over their leased grounds at a concentration of 400 to 800 boxes per acre. The relay oysters remain there until the fall marketing season. Then they are harvested by either tonging, power dragging from a lobster boat, forking, or by hand. With tongs one can harvest about 20 boxes of relay oysters per day from a well-stocked leased ground, or about 10 times faster than oysters are harvested on public beds. This is because cleaning is unnecessary, as oysters are unclustered and have no seed oysters attached.

I designed a hand drag to enable fishermen to harvest oysters faster and easier on leased grounds with soft bottoms (Fig. 12). A special feature of the drag is a 1-inch diameter bar and side runners that keep it from sinking into the mud. The bar has a row of 3-inch teeth welded onto it that pulls oysters out of the mud as it is towed. The drag has a long, light-weight but strong bridle that makes it easy for a fisherman to pull it into his dory for dumping. The drag holds about 3 pecks of oysters. When it is used for harvesting oysters, a single fisherman harvests oysters

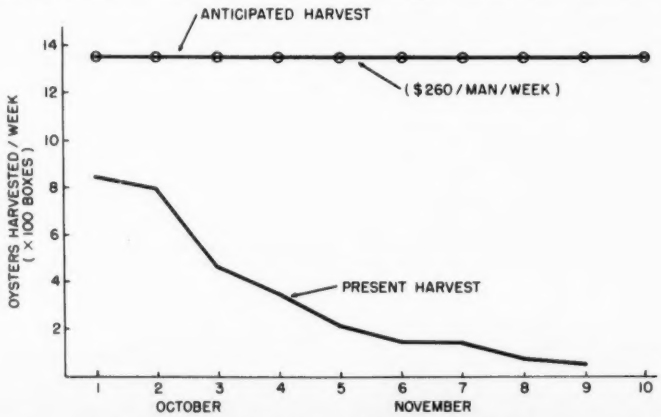

Figure 11.—Present harvest and possible harvest yields of oysters in East River. The anticipated yield is that expected after recommended management program is conducted.

about twice as fast as by tonging, and the work is easier.

Oysters sold for market are carefully graded according to shape into one of four categories, namely, fancy, choice, standard, and commercial, in order of descending value. Then, they are packed in individual 5-peck (1¼-bushel) wooden or cardboard boxes. Before it is sealed shut, every packed box is examined and stamped by an inspector of the Federal Fisheries Service, who visits each grading house about twice a week.

Economic Factors of Fishing and Buying

Expenses and Earnings of Public Fishermen

It might appear that the cost of entering the public oyster fishery is slight and gross earnings are virtually all profit, but actually the entering cost and expenses amount to a considerable proportion of gross earnings. Morse (1971) is not correct in stating that the entering cost and expenses are both low.

The cost of fishing can be broken down into three major categories: gear, habitation, and travel. The current cost of new gear necessary to enter the fishery is about $1,000 and the cost of a fitted trailer is about $500. Travel cost is extra (Table 2). Actually, few men purchase this gear new when they enter the oyster fishery but obtain much of it second-hand, especially more expensive items such as the outboard motor. An entering fisherman may share a trailer and travel between home and the fishing area with someone else. The cost per week of each is: owning and using gear, $25; habitation, $9.00; and travel, $13.50; or a total of about $47.50 (Table 2). The cost of food is about $15 extra.

Figure 12.—A hand drag designed for harvesting oysters on soft leased areas. The thick toothed bar and runners prevent the drag from sinking into mud as it is towed.

Table 2.—Weekly costs of a typical oyster fisherman during two seasons (10 weeks in spring, 9 weeks in fall).

	Item	Purchase cost ($)	Longevity	Cost/year ($)	Cost/week ($)
I.	GEAR				
	Dory	125.00	5 years	25.00	1.31
	Outboard motor	750.00	6 years	125.00	6.58
	Gas can	42.00	4 years	10.50	0.55
	Gas and oil	(0.72/gal)			1.68
	Dory cable (rope)	2.50	2 years	1.25	0.07
	Anchor	10.00	5 years	2.00	0.10
	Paint for dory/gal	10.00	½ year	20.00	1.05
	Tongs (3 pairs)	60.00	1 year	60.00	3.16
	Gloves/pair	1.50	1 day	118.20	7.88
	Oil clothing	24.00	coat: 3-4 seasons pants: 1 season	15.00	0.79
	Boots	14.00	1 year	14.00	0.74
	Oyster boxes (12)	18.00	1 year	18.00	0.95
	Subtotal	1,057.00		Subtotal	24.86
II.	HABITATION				
	Trailer	425.00	10 years	42.50	2.24
	Heating stove	70.00	7 years	10.00	0.53
	Heating oil	(0.50/gal)	8 gal/week	60.00	4.00
	Cooking stove				1.00
	Cooking gas				1.00
	Trailer license	5.00	1 year	5.00	0.26
	Subtotal	500.00			9.03
III.	TRAVEL				
	1,825 miles year	gas, oil, tires		96.00 10.00	5.07 0.53
	Depreciation of vehicle	⅓ year		150.00	7.90
				Subtotal	13.50
				Grand total	$47.39

During the spring season, weekly earnings range from about $100 to $145 (depending upon the capability of the individual fisherman) averaging about $130 (Fig. 9). Earnings remain about constant during the entire season, except for a slight drop during June when oysters become scarce. Afterward, the harvest rate improves as the undersized oysters reach marketable size. The average fisherman who remains for the entire season earns about $1,300.

During the fall season, weekly earnings average $160 (range, $100 to $200) at the beginning, and $100 at the end (Fig. 10). Harvests and earnings vary considerably from week to week, however, owing to adverse weather. The average fisherman earns about $1,000 during this season.

The entry cost into the public oyster fishery is significantly greater than the gross earnings during either season, and weekly expenses consume about 35 percent of gross weekly earnings, leaving the fisherman with a net income of about $85 before meal costs.

Expenses and Profits of Oyster Buyers

Buyers, who purchase relay oysters during the spring oyster season for spreading on their leased grounds until fall season, pay about 70 percent as much as for fall oysters, but their profit margin is about the same in each season. In spring, the usual price paid for relay oysters is $11 to $12 per box. While oysters are carried on leased grounds, about 10 percent are lost through mortality. Accordingly, a recovered box actually costs the buyer about 11 percent more than the original price or about $13.30 for a $12 box. (These oysters improve slightly in grade, partially recovering this loss.) In addition, it costs the buyer about $5 to harvest, clean, grade, pack, and place the relay oysters in a truck (this includes the $1.25

box cost). The extra costs of spreading oysters, the boat, shovels, drags, tongs, and forks, telephone calls, transportation between home and the grading house are estimated to be $2.00 per box. Thus, the total cost of a box of relay oysters ready for shipping to market is $20.30. In 1971, the buyers received an average price of $24.60 per box of oysters, netting about $4.30 per box.

In fall 1972, the average price the buyers paid for oysters from public grounds was $17.50 per box. It costs $1.25 to grade and pack, and $1.25 for a box. Thus, the total cost for a box of oysters was $20.00. Since buyers sold these for the same price as relay oysters, $24.60 (average) per box, their gross profit was $4.60 before overhead, an estimated $1.00 per box. Therefore, the net profit was about $3.60 per box.

In 1972 the percentages of oysters sold in each grade were: fancy, 3; choice, 35; standard 43; and commercial, 19.

Nearly all oysters are shipped to cities of eastern Canada (the largest market is in Montreal) for consumption raw on the half shell. Although all grades of oysters have about the same meat content and excellent flavor, consumers place high value on shell shape. A small quantity of oysters is sold on the Island, both in the shell and shucked. Medcof (1961) reported that P.E.I. oysters have a dry storage life of approximately 4 months if held under proper conditions.

Leased Ground Fishery

In 1973, there were 1,038 leased grounds on P.E.I. that covered about 3,700 acres; they yielded about 2,000 boxes of oysters per year (0.5 box per acre, average). It is not feasible to culture oysters (to collect or buy seed oysters and grow them to market size) on most of these grounds for several reasons. Aside from the poor environment provided for oysters described above, procuring and rearing seed oysters to market size is risky and economically marginal; oyster poaching is extensive; and market demand is variable.

There are mixed opinions of advantages of private ownership. Morse (1971) states: "A shift in policy to convert the public beds to privately managed grounds probably would result in an increase in output, and in income earned, from these areas." However, some sections of public beds already produce high yields, near the maximum that can be produced, without any management. These yields could not be increased under private ownership. More importantly, only a few fishermen, the ones who obtained grounds with oysters on them, would stand to gain by such a shift; they could use a drag to harvest more market oysters off these grounds than they could with tongs. However, the remaining fishermen, those receiving barren grounds, would lose, since they would be excluded from the productive beds. Even though the environment is good for culturing oysters on the barren grounds in Bedeque Bay and East River especially, I believe it would be extremely difficult to begin a profitable enterprise on them for reasons described above.

Most leased grounds should be used to hold over summer market-size relay oysters that are harvested during the spring season for sale in the fall. This practice of purchasing and selling relay oysters is a good business proposition. Relay oysters will survive on nearly all leased grounds in spite of the generally poor environment.

DEVELOPMENT OF MANAGEMENT PROGRAM

The management program for the oyster industry was developed by identifying the needs within the three sectors, reviewing biological and ecological potentials for enlarging and increasing the number of oyster beds, and conducting pilot projects in which large vessels transplanted stocks of oysters and shells.

Identification of Needs Within Industry

Improvements in any production system, such as the oyster industry on P.E.I., should be designed to benefit all sectors. Basically, improvements should result in higher earnings, greater employment, lighter workloads, and improved health. A significant improvement in one sector will affect the others, and thus it must be examined for its effects before any implementation is made, to ensure that it will indeed be beneficial to the whole. If any one sector stands to lose by an improvement in another sector, doubtless that sector will not accept the change. The result would be that the improvement could not be implemented.

An essential step in the process of making improvements in a traditional system of oyster culture lies in acquiring a thorough understanding of the needs within each production sector and then finding and developing ways to satisfy those needs. One approach is to provide better alternatives to existing methods or policies, as recommended in the field of agriculture by Schultz (1964). All oyster industry sectors are marginal; thus, none can afford to invest money, labor, or time in new developments. Ideally then, improvements should provide sure and immediate gains.

There are three basic production sectors of the oyster industry; the public fishermen, the buyers (leaseholders), and the wholesalers. The basic needs of each follow.

Needs of Public Fishermen

Information for this section was obtained from interviews with fishermen. The public fishermen need: increasing harvests per unit time (larger and denser beds with reduction in cleaning time); more high grade oysters to bring higher prices; lighter workloads; and better living conditions. If all these needs were satisfied, fishermen would earn more, be healthier, and have longer effective working lives.

Needs of Buyers (Leaseholders)

Information for this section was obtained from buyer interviews. The buyers, whether they purchase relay oysters in the spring for holding on their leases until the fall marketing season, or purchase oysters from public fishermen in the fall, need: a larger volume of oysters to handle for higher incomes; more high-grade oysters to satisfy the stronger demand; better protection from poaching; and more efficient equipment for harvesting.

Needs of Wholesalers in Cities off P.E.I.

Information for this section was obtained by telephone interview with a Montreal wholesaler. The wholesalers need: a much larger, dependable supply of oysters to encourage and maintain consumer demand; and more high grade oysters, for which the demand is stronger.

It can be seen that a larger supply of oysters with higher quality on both spring and fall public oyster grounds would satisfy the basic needs of all three production sectors. Accordingly, my objectives focussed on devising a management program to expand the oysters on both types of grounds, and to improve the quality of oysters on those beds.

Biological and Ecological Potentials

The biological and ecological potentials for increasing the number and size of commercially valuable oyster beds in Bedeque Bay and East River are substantial. Virgin beds exist in both estuaries. Oysters could be transplanted from these beds, in an orderly way so as not to deplete them, and spread over good quality barren grounds towards the mouths of the estuaries. These oysters would reproduce regularly and grow rapidly, attaining market size in no more than 4 years. Little mortality on the newly-established beds would occur in Bedeque Bay, but starfish do inhabit some grounds in East River. Avoiding high concentrations of starfish or some predator control might be necessary when spreading oysters over barren river grounds.

Important factors in evaluating the attributes of vacant public grounds as adequate oyster environments include: protection from storms; ground firmness for inducing growth of a round, cupped shell (fancy or choice grade); water depths of 3 to 4 feet (low water) to prevent ice from killing oysters, to avoid starfish, and to enable fishermen to harvest easily; regular setting in order that a new oyster bed will be self-perpetuating (if setting were not regular, these grounds would require refilling periodically); and presence of tube worms. Almost 600 acres of good quality barren ground are available in Bedeque Bay, 100 acres in the fall harvesting zone, and several hundred acres in the East River spring fishing zone.

Finally, estuaries currently producing commercial quantities of oysters under no management have far greater potential for an increase in production than unproductive ones. Equal investment of effort in estuaries that do not produce many oysters would yield smaller returns. Therefore, in selecting estuaries for development, those that produced the most oysters, Bedeque Bay and East River, were given priority.

Shell deposits that can be mined and used as a cultch source occur in most estuaries. In Bedeque Bay, shell deposits occur near oyster beds. In East River, the shells would not have to be mined and respread; rather, they would be prepared in place when oysters are dragged from the channel beds.

Use of Large Vessels

The most efficient and rapid means of increasing oyster production and industry earnings is to use large oyster vessels to transplant oysters and shells within public grounds. Large vessels can transplant large volumes of oysters from harvested virgin beds to good quality barren bottoms, within a short time and at relatively low cost. The area of productive oyster beds in Bedeque Bay and East River could be increased fivefold within only a few years.

A functional way to increase earnings of fishermen is to improve oyster quality, since the price differential between grades is wide (3.5 times). For example, in fall 1972, the price per box to public fishermen of fancy grade oysters was $28, choice grade $25, standard grade $15, and commercial grade $8. Transplantation of oysters by large vessels can significantly improve oyster quality and value as clusters are broken apart during this process. The separation not only enables oysters to grow into better shapes but also means that fishermen can harvest and clean them more rapidly. In Bedeque Bay, oysters will be transplanted from shallow flats, where tube worms are scarce, to hard grounds covered by 3 to 4 feet of water at low tide, where these worms are abundant. In East River, oysters will be transplanted from the channel to hard grounds where they can be harvested by fishermen and tube worms are abundant.

The costs of enlarging or establishing new oyster beds would be low in relation to the benefits as this involves only the transplantation of existing oysters. Similarly, costs of mining and spreading shells in Bedeque Bay to sustain the original oyster beds would also be low relative to benefits because annual oyster setting on shells is virtually certain. Undoubtedly, the stocks spread on most new grounds will be self-perpetuating, owing to regular natural setting. Accordingly, they would yield oyster harvests year after year, at no additional cost beyond that of the initial establishment of the beds.

The operation of large vessels on public grounds could be financed by public funds under the direction of a government fisheries agency. The general management program suggested is similar to those used by most coastal states in the United States. The large oyster producing states such as New Jersey, Delaware, Maryland, Virginia, Florida, Alabama, Mississippi, Louisiana, and others sponsor programs to maintain oyster beds on public grounds. Collectively, the programs involve the mining and spreading of several million bushels of shells to collect seed oysters, and transplanting of seed oysters with large vessels.

These programs produce large cost-benefit ratios. For example, Whitfield (1973) stated that man-established oyster beds in Florida that produce for 20 years, as some already have, result in a cost-benefit ratio at the fishermen's level of 1 to 100. He states further that oyster bed rehabilitation in Louisiana has resulted in cost-benefit ratios as high as 1 to 20.

PILOT PROJECTS CONDUCTED

Three pilot projects were begun during the investigative period. These were considered as pilot projects as no management plan had as yet been formalized; but the last two were effec-

tive enough already to have made significant improvements in the oyster industry.

The first project was conducted in East River, in which barren grounds were stocked with oysters that had been dragged from the virgin bed in the upper river, during fall 1972. A scallop boat fitted with an oyster drag was chartered to harvest the oysters. During an 18-day period, it harvested about 2,000 boxes of oysters. Approximately half were sold to East River leaseholders at low cost, while the remaining half were spread on public grounds. Review of this project showed that it would be of greater total benefit to spread all oysters dragged from the channel on public grounds. The environment for oysters was better on those grounds and the leaseholders would be spared from paying for the oysters—they could harvest them on public grounds.

The second project was a larger-scale transplantation in East River involving use of an oyster boat, a catamaran-type vessel constructed especially for these projects (Fig. 13). No existing vessels suitable for transplanting oysters were available in the Maritimes. The catamaran had a capacity of about 225 boxes of oysters. Its two drags could be raised 5 feet above its deck by booms and the oysters were dumped by releasing a door on the drag (Fig. 14). Oyster clusters were partially separated when they fell on the deck (Fig. 15). The oysters were spread overboard by hosing with water. During the summer of 1973, about 15,000 boxes of oysters were transplanted by the catamaran from section No. 1 in the virgin oyster bed in the upper river (Fig. 6) and spread on three good-quality barren grounds, whose combined areas totalled 30 acres, below Glenfinnan Island. Each box contained about 1,000 oysters of mixed ages and sizes. The rate of spreading was 500 boxes per acre. After the oysters had grown during the summer of 1973, the concentration was about 800 boxes per acre in the fall, a concentration optimum for harvesting. The oldest oysters were slightly smaller and they had poorer shell shapes than oysters on other public beds in the river, but clusters were broken apart to about twice the extent as the others. Accordingly, it is anticipated that they will eventually grow into better shapes than the others. The transplanted oysters were too small for harvesting in the fall of 1973, but by 1974 they were expected to provide an additional 30 acres of productive beds.

The virgin oyster bed in East River lies on a continuous deposit of oyster shells. During the oyster transplanting operation, mud was scoured off the bottom, and consequently the underlying shells were clean before the oyster setting season. During July the shells received a heavy set of oysters over an area of several acres where oysters had been harvested previously. After a few years, this ground should be replenished with a large bed of oysters of several age groups.

The third project was conducted in Bedeque Bay. It consisted of transplanting small, poor-quality oysters from plots within oyster beds, spreading them on barren grounds west of and adjacent to the harvesting areas, and then spreading mined shells over the dragged plots (Fig. 5). Some 1,600 boxes in Wilmot River and 17,000 boxes in Dunk River were transplanted to 4-acre and 34-acre plots respectively, alongside the western borders of the fishing areas. Each box contained an average of about 450 oysters of various age groups.

Some oysters were to have been harvested from this area in 1974, and it should reach full commercial productivity in 1975.

During the oyster setting season, some 3,500 boxes of shells that had been mined from a deposit about a mile away were spread over the two plots. Additional shells were not required because shells buried in the bottom within the dragged plots were lifted to the surface during the dragging operation. Most shells collected a heavy set of oysters.

With the use of the oyster catamaran, oysters and shells were transplanted at low cost. In Bedeque Bay, it costs an average of $0.85 to transplant a box of oysters, or $425 to spread 500 boxes of oysters over an acre; and in East River, an average of $0.65 to transplant a box of oysters, or $325 to spread 500 boxes over an acre. These costs approximate those for transplanting oysters in the United States. It costs about $1.25 to mine and transplant each box of shells in Bedeque Bay. Although this figure is higher than the usual cost for shelling grounds in the United States, the near certainty that spread shells will collect oyster spat still makes mining and transplanting of shells an excellent economic proposition.

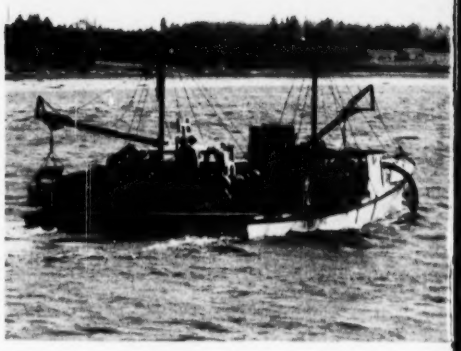

Figure 13.—Catamaran with part of an oyster load on its deck in East River. Note booms that lift drags.

Figure 14.—Clusters of oysters dropped from the drag are partially separated when they hit the platform.

SPECIFIC MANAGEMENT PROGRAM

The management program for oysters is not complex, but involves transplanting sufficient oysters to cover and establish new beds on 70 or more acres of barren bottom each year.

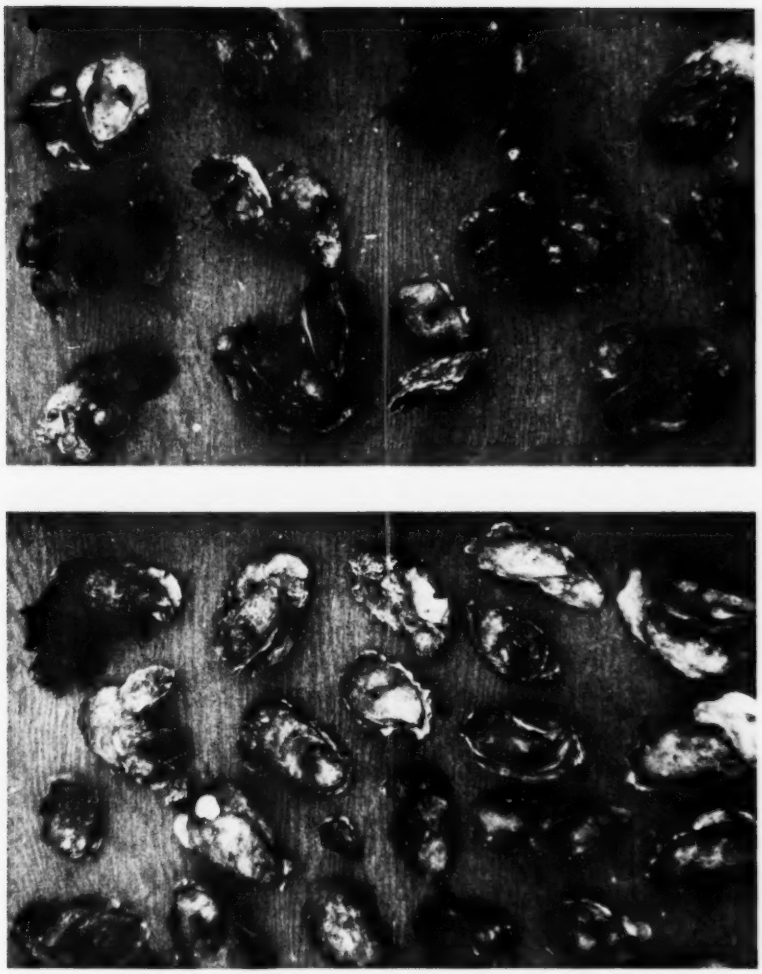

Figure 15.—Samples of oysters before (upper) and after (lower) drop onto catamaran, showing extent of cluster separation as a result of the drop.

Some additional suggestions for increasing production and earnings and industry development are listed below under the section on applied research.

Transplanting of Oysters and Shells

In Bedeque Bay, transplanting of oysters from harvested sections to good-quality barren grounds of Wilmot and Dunk Rivers should be continued each year. A total of 4,000 boxes in Wilmot River and 16,000 in Dunk River will be transplanted and spread over 40 acres. More oysters could be transplanted if two or more catamarans were available to do the work. Eventually, the barren 100 acres in the mouth of Wilmot River and the barren 500 acres in the mouth of Dunk River may be covered with oysters (Fig. 5). Ample shells will be spread on the cleared sections to sustain the original stocks.

In East River, transplanting oysters from the virgin bed in the upper river to good-quality barren grounds in the lower river should be continued each year. A total of 15,000 boxes of oysters from the bed will be transplanted and spread over 30 acres. Eventually, the barren 100 acres in the fall harvesting zone and an even larger area in the spring harvesting zone may be covered with oysters.

The bed contains about 106,000 boxes of oysters and covers 140 acres. It has been divided into four sections: the upper two sections each will have about 25 acres (25,000 boxes) and the lower two sections, 45 acres (28,000 boxes). From early May to mid-June, the boat will transplant 15,000 boxes from a section as designated in Figure 6. Oysters were transplanted from section No. 1 in 1973. The intention was also to transplant from section No. 2 in 1974, from section No. 3 in 1975, from section No. 4 in 1976, and section No. 1 again in 1977, etc. By transplanting as many oysters as possible before they begin pumping in spring, those that would be suffocated in silt deposits would be saved. After oysters are transplanted from a section, the entire bottom will consist of clean shells as well as the oysters that remain. It is anticipated that young oysters in adequate numbers will set on shells and oysters as they did in 1973 and, in later years, on growing oysters. Ultimately, the bed should consist of the same numbers and sizes of oysters it had before it was dragged. Accordingly, about 15,000 boxes of oysters could be dragged off each section every fourth year in rotation.

Anticipated Increases in Production

It is difficult to forecast production from oyster beds accurately as many factors are involved. A means of forecasting production of oysters from newly-established beds is to examine production from existing beds. The most productive public beds yield an estimated 150 boxes of oysters per acre per season. If we take a more conservative average yield of 100 boxes per acre per season, yields at that level from the new beds can be forecast. In Bedeque Bay, the oyster yield from 40 acres should be about 4,000 boxes, and in East River from 30 acres, about 3,000 boxes. Thus, if about 70 more acres of beds are added to the existing beds each year, oyster production would probably increase at an annual rate of about 7,000 boxes.

The potential for increasing oyster production, however, hinges on more than increasing available supplies. It also hinges on both fishing pressure and the ability of buyers and wholesalers to purchase sudden increases in production.

It is possible that the supply of oysters on public grounds might eventually outstrip the fishermen's harvesting

capacity after the management program has been underway for a few years. In that event, increased production could be attained by allowing fishermen to harvest oysters with hand drags (Fig. 12), instead of tongs. A limit could be placed on the number of days, or weeks, that drags could be used to control harvest rates, if warranted.

Anticipated Increases in Earnings

In Bedeque Bay, weekly harvests of individual fishermen should increase from 10 to 15 boxes and remain that high during the entire season. Accordingly, weekly earnings of individual fishermen should rise from $130 to $195, and seasonal earnings from $1,300 to $1,950 (Fig. 9).

In East River, weekly harvests of fishermen at the season's beginning should rise from 8 to 14 boxes, and remain that high during the entire season (Fig. 11). Accordingly, weekly earnings of individual fishermen should rise from $130 to $260, and seasonal earnings, from $1,000 to $2,600. (The fall season would be extended to 10 weeks.) In some years, poor weather will reduce these earnings.

It is anticipated that the quality of oysters in both Bedeque Bay and East River will increase by about half a grade, and lead to an increase in the price of about $4.50 (average) per box in the fall. This increase is not included in the projections listed above.

The earnings of the typical fisherman will increase from $1,300 to $1,950 during the spring season, and from $1,000 to $2,600 during the fall season, increasing combined earnings from $2,300 to $4,550. The two remaining industry sectors would also benefit: the buyers on P.E.I. would earn more money, since they would handle greater volumes of high-quality oysters; the wholesalers in off-Island cities would earn more money, since they, too, would have more high-grade oysters to handle and could rely on a dependable supply.

Possible Negative Aspect

It is likely that a significant increase in quantities of high-quality oysters on public grounds will lure into the oyster fishery many more men who will anticipate good earnings. Although this would have the effect of increasing the level of gainful employment on P.E.I., the additional number of men may be sufficiently large to effectively negate any potential gain in earnings intended for the regular fishermen. The new entrants might not only compete for the same oysters, but also increase production sufficiently to result in a drop in prices.

This rehabilitation program was intended to spread out the increased oyster quantities for the regular fishermen over an entire season. Accordingly, it is proposed that a limit be placed on the number of new entrants into the public oyster fishery, to ensure that the regular fishermen do, indeed, gain the projected increased harvests and earnings. Under a limited entry plan, a controlled number of men would be permitted to enter the oyster fishery if warranted by adequate supplies and market demand each year.

COST-BENEFIT RATIOS

The monetary benefits to be gained from stocking previously barren grounds with oysters to establish new beds should far exceed costs. Indeed, during each season the amount of money earned by fishermen from a newly established bed should far exceed initial costs. For example, the cost of stocking an acre in Bedeque Bay was $425, and the anticipated earnings from an acre are $1,200 per season ($12 per box of oysters × 100 boxes harvested); the cost of stocking an acre in East River was $325, and the anticipated earnings are $1,750 per season ($17.50 per box of oysters × 100 boxes harvested). On those beds that perpetuate themselves through natural setting, cost-benefit ratios may ultimately exceed those reported for the United States, 1 to 20 and as high as 1 to 100, as costs are about the same and the sale value of P.E.I. oysters is greater.

APPLIED RESEARCH NEEDED

A list is presented of some key studies that could be pursued further to develop the oyster industry.

I. Oyster biology and ecology
   a) Studies, more detailed than were made during this investigation, of causes of oyster mortalities during various seasons to refine management procedures.
   b) Studies of starfish biology, such as migration patterns, recruitment rates, seasonal feeding rates, food preferences, and factors affecting distribution.
   c) Studies of tube worm biology, such as seasonal recruitment, growth rates, longevity, and factors affecting distribution.
   d) Studies of oyster genetics to determine the extent that shell shape of parent oysters influences shape of offspring.
   e) Studies to determine both the sources and seasonal deposition rates of silt, its precise effects on oyster beds, and the feasibility of slowing its flow into estuaries.

II. Oyster culture
   a) Studies to determine the cost-benefit ratio of increasing grades of oysters on already productive public oyster beds by transplanting them every year, separating any clusters.
   b) Studies to ascertain whether oyster clusters can be separated by towing a device such as an agricultural cultivator over a ground. Separation of clusters to improve the quality of oysters would bring some beds into production where harvesting does not occur because oysters have poor quality.
   c) Studies to determine whether dormant shell deposits can be converted to productive oyster beds again by towing over them a device such as a toothed oyster drag that is 6 or more feet wide. The teeth would loosen the shells and the drag's pressure plate would scour silt off the ground.
   d) Studies to determine the feasibility of using quicklime (CaO) to control starfish, sea lettuce, and the biota on live oysters and exposed shells. Advantages of control of the first two types are obvious. Control of the latter before the setting season of oysters would provide more and better setting surface for oyster larvae, resulting in heavier sets.
   e) Studies to explore the feasibility of mining shells for storage

on land. Leaseholders with proper grounds need a convenient supply of shells for collecting seed oysters.

f) Studies to explore the means of extending the time that oysters are available for market. An extension is needed because, at present, the fresh supply is terminated when ice forms over the estuaries.

III. Social needs

a) Studies to determine the feasibility of providing temporary or mobile kitchens at shore sites near the major public beds, to provide better meals for fishermen.

b) Studies to determine whether bunk houses could be built at shore sites in order that men who do not own trailers might easily enter the public fishery.

IV. Economic needs

a) Studies to determine whether low cost government sponsored loans should be made available to oyster buyers during the spring oyster season. It is possible buyers may not have extra funds to purchase the projected increases in oyster harvest by fishermen. In that event, production increases would not take place, unless additional buyers were found.

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MFR PAPER 1130

An Analysis of Prices Paid to Fishermen Before and After the Establishment of a Fishery Cooperative

CHARLES W. LAMB, JR.

INTRODUCTION

"A fishery cooperative consists of a group of individual fishermen acting together for mutual benefit and is designed to accomplish group objectives" (Smith, 1974). These group objectives are primarily economic in nature and often directly related to the prices paid to the fishermen for their catch. Common motivations to create fishery cooperatives include excessive price fluctuations, weakness of prices at the primary producer level, and/or insufficient storage and processing facilities.

This paper reports the findings of a case study which compared the prices received by fishermen prior to and after the establishment of a unique fishery cooperative organization.

BACKGROUND

In January, 1965 the Federal-Provincial Conference on Fisheries Development in Ottawa, Ontario included discussions on the marketing problems facing the inland freshwater fish industry of Canada. These deliberations led to the establishment of the Inter-Governmental Committee on Marketing Organization for the Freshwater Fisheries, which later became the Sub-Committee of the Federal-Provincial Prairie Fisheries Committee on Marketing Organization. This subcommittee was charged with the responsibility of evaluating the feasibility of adopting marketing board techniques within the industry. Its recommendations resulted in the formation of the Commission of Inquiry into Freshwater Fish Marketing under the leadership of George H. McIvor. The charge to the Commission read:

> The Commission is hence instructed to inquire into and report upon the possibility of better coordination which will achieve more orderly marketing . . . and report upon whether the current marketing situation warrants an export monopoly, whether persons and organizations involved in the marketing process want organized marketing; and whether an export monopoly or marketing board technique of selling can work for marketing freshwater fish (McIvor, 1965).

Finally, based upon the findings of the McIvor Commission, the Senate and House of Commons on 27 February 1969 passed legislation creating a Crown corporation named the Freshwater Fish Marketing Corporation.

The Corporation was established as the sole interprovincial and export seller of the products of the commercial freshwater fisheries of the provinces of Manitoba, Alberta, and Saskatchewan, the Northwest Territories, and the northern portion of Ontario. The objectives of the Corporation, as established by law, are: a) the marketing of fish in an orderly manner; b) increasing returns to fishermen; and c) promoting international markets for, and increasing inter-provincial and export trade in, fish (Acts of the Parliament of the Dominion of Canada, 1969).

Products

The primary species of the Canadian freshwater fishery are whitefish, pickerel, pike, sauger, and trout. In 1968 these five species accounted for roughly 37 percent of the total commercial landings of freshwater fish in Canada, and over 62 percent of its landed value (Anonymous, 1972). Other species indigenous to the freshwater fishery include tullibee, perch, goldeye, mullet, cisco, sucker, redhorse, turbot, sheepshead, and buffalo fish. Historically, these species have been of low commercial value and at best considered by-products of fishing for the higher priced species. Many of these underutilized or underexploited species are available in abundant supply.

Markets

The Canadian freshwater fishery is heavily dependent on export markets for the sale of its products. More than 80 percent of all commercial freshwater fish landings are exported and 95 percent of this volume flows to the United States.

OBJECTIVE

The objective of the study was to determine whether or not returns to fishermen have increased since the establishment of the Freshwater Fish Marketing Corporation. Three criteria were selected to evaluate the Corporation's efforts to increase returns to

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fishermen. These criteria are: a) changes in average prices received by fishermen for the combined landings of the five primary species; b) changes in average prices received by fishermen for the combined landings of all species; and c) changes in the percentage of export price paid to fishermen.

PRICES RECEIVED BY FISHERMEN

Prices received by fishermen, which are best measured in terms of real landed price per pound, can be analyzed both by species and by province. Since the primary concern is to determine if fishermen are receiving greater overall returns per pound in the total area under the jurisdiction of the Freshwater Fish Marketing Corporation, changes in prices for particular species or in specific provinces will not be considered. Therefore, analysis will be restricted to a) the average real prices per pound received by fishermen for the combined landings of the five primary species in the participating provinces, and b) the average real prices per pound received by fishermen for all species landed in the participating provinces.

In order to determine if landed value per pound increased following the creation of the Corporation, the following null hypotheses were tested:

1) The average real price per pound paid to fishermen for the combined landings of pickerel, sauger, trout, and whitefish harvested in Ontario, the prairie provinces, and the Northwest Territories was not higher following the establishment of the Freshwater Fish Marketing Corporation than before it was created.

2) The average real price per pound paid to fishermen for the combined landings of all species harvested in Ontario, the prairie provinces, and the Northwest Territories was not higher following the establishment of the Freshwater Fish Marketing Corporation than before it was created.

Defining μ_1 as the mean real price per pound paid to fishermen for the combined landings of the five primary species of Ontario, the prairie provinces, and the Northwest Territories before the Corporation was established, and μ_2 as the mean real price per pound paid to fishermen for the combined landings of the five primary species in Ontario, the prairie provinces, and the Northwest Territories after the Corporation was created, the first null hypothesis can be stated H_0: $\mu_1 - \mu_2 \geq 0$, with the associated alternative hypothesis H_1: $\mu_1 - \mu_2 < 0$. Similarly, defining μ_3 as the mean real price per pound paid to fishermen for the combined landings of all species in Ontario, the prairie provinces, and the Northwest Territories before the Corporation was established, and μ_4 as the mean real price per pound paid to fishermen for the combined landings of all species in Ontario, the prairie provinces, and the Northwest Territories after the Corporation was created, the second null hypothesis can be stated H_0: $\mu_3 - \mu_4 \geq 0$, with the associated alternative hypothesis H_1: $\mu_3 - \mu_4 < 0$.

The *t*-test of the difference between two means was used to test the null hypotheses. The assumptions of this test are: a) the real prices are random variables from normal populations, and b) the variances of the parent populations are equal. In this case a further assumption must be made; namely, that neither the means nor the variances of the parent populations are a function of time. This assumption is supported by the results of multiple regression analysis which indicated that time trend, price in the previous year, and landed pounds were all poor indicators of the average real price of fish for any given year.

To test the two null hypotheses, the appropriate mean real price for the three years prior to the establishment of the Corporation was compared to the mean real price for the three years after establishment of the Corporation (Table 1). Therefore, each test had four degrees of freedom.

As Table 2 shows, the first null hypothesis could be rejected at the 0.148 level of significance. This indicates that the change in average real price per pound paid to the fishermen for the combined landings of the five primary species after the Corporation began operations is not statistically significant at a reasonably low level of significance. Therefore, the null hypothesis $\mu_1 - \mu_2 \geq 0$ cannot reasonably be rejected. In other words, it cannot be concluded that the average real price per pound fishermen received for the five primary species increased after the Corporation was established.

Table 2 also shows that the second null hypothesis could be rejected at the 0.005 level of significance. This

Table 1.—Index of prices received by fishermen, 1966-1971 (1935-1939 = 100) (values in cents per pound)

		Five Primary Species		All Species	
Year	Wholesale price index	Average landed value per pound	Deflated Average landed value per pound	Average landed value per pound	Deflated average landed value per pound
1966	259.5	21.1	8.13	12.2	4.7
1967	264.1	16.9	6.40	11.1	4.2
1968	269.9	18.8	6.97	11.3	4.2
1969	282.4	22.6	8.00	13.1	4.6
1970	286.4	21.6	7.54	14.8	5.2
1971	289.9	20.3	7.00	16.2	5.6

Source: Canada, Department of the Environment, Intelligence Services Division, Marketing Services Branch, Fisheries Service, *Annual Statistical Review of Canadian Fisheries*, Vol. 4, 1972.

Table 2.—Results of *t*-Test*

	$\bar{X}_1$	$\bar{X}_2$	$s_{\bar{x}_1 - \bar{x}_2}$	Computed t	Significance probability**
Avg real price/lb for the 5 primary species	7.15	7.51	0.300	−1.20	0.148
	$\bar{X}_3$	$\bar{X}_4$	$s_{\bar{x}_3 - \bar{x}_4}$	Computed t	Significance probability**
Avg real price/lb for all species	4.36	5.13	0.169	−4.55	0.005

*Values used to compute $\bar{X}_1$, $\bar{X}_2$, $\bar{X}_3$, and $\bar{X}_4$ can be found in Table 1.

**Significance probabilities reported in Table 2 correspond to the minimum levels of significance for which the associated null hypotheses could be rejected.

$\bar{X}_1$ = The sample mean of average real prices per pound for the primary species for the three year period before the Corporation was created.

$\bar{X}_2$ = The sample mean of average real prices per pound for the primary species for the three year period after the Corporation was created.

$\bar{X}_3$ = The sample mean of average real prices per pound for all species for the three year period before the Corporation was created.

$\bar{X}_4$ = The sample mean of average real prices per pound for all species for the three year period after the Corporation was created.

$s_{\bar{x}_a - \bar{x}_b}$ = the estimated standard error of the difference between the two means.

indicates that the change in average real price per pound paid to the fishermen for the combined landings of all species after the Corporation began operations in 1969 is statistically significant. Therefore the alternative hypothesis $\mu_3 - \mu_4 < 0$ is to be accepted. In other words, it can be concluded that the average real price per pound paid to fishermen for species other than the five primary species increased after the Corporation was created.

A possible explanation of why average real prices increased for other species, but not for the five primary species, is that species of fish previously not commercially exploited are now being introduced on the market in new product forms. These essentially new products command a higher market price which can ultimately be passed back to the fishermen.

This explanation, although tentative, is supported by findings previously presented elsewhere (Lamb, 1974). For example, prior to the creation of the Corporation, processing operations in the industry were limited to simple filleting. The Corporation, on the other hand, has invested in expensive, sophisticated machinery and equipment which is capable of performing a variety of technologically advanced processing operations. This new production capacity combined with large, modern cold storage facilities and the Corporation's expansion into the convenience food market has made the underutilized species more desirable, thus more profitable to the fishermen. The five primary species, which were previously considered the mainstay of the industry, have continued to be marketed primarily whole and filleted. Since these products are marketed in essentially the same form as before the corporation was created, their real price per pound has not increased.

PERCENT OF EXPORT PRICES PAID TO FISHERMEN

The third criterion selected to evaluate the Corporation's efforts to increase returns to fishermen is a comparison of the percentage of export prices paid to fishermen before and after the Corporation began operations.

For the 3-year period prior to the creation of the Corporation, fishermen in the participating provinces received an average of 69 percent of the export price of fish. For the 3-year period following the creation of the Corporation, fishermen in the participating provinces received an average of 67.4 per cent of the export price of fish (Anonymous, 1972). In other words, the percentage of export prices paid to the fishermen decreased slightly after the Corporation was created.

One possible explanation why the Corporation has not increased the percentage of the export price paid to fishermen might be that marketing costs have not changed; therefore the percentage of export prices paid to fishermen has not increased. This is a weak argument however, because one of the reasons the Corporation was created was to reduce the margin between prices to fishermen and export prices. The McIvor Commission noted:

> There is a large spread between the price received by the exporter-processor and the price paid to the fisherman . . . The Commission finds that on average the spread is excessive because handling, processing and storing are inefficient (McIvor, 1965).

It is therefore concluded that, regardless of the reason, the Corporation has failed to reduce the margin between prices paid to fishermen and export prices. This is clearly an area for more detailed study by the Corporation.

SUMMARY

In sum, the change in average landed price per pound for all species since the Corporation began operations in 1969 is statistically significant. Fishermen have benefited from the Corporation's development of markets for previously underutilized species. Prices paid the fishermen for these species have increased, apparently as a result of advanced processing techniques the Corporation has adopted and its development of markets for these species in new product forms.

Two areas are apparent where the fishermen are not better off than they were prior to the establishment of the Corporation. Landed price per pound for the five primary species did not significantly increase after the creation of the Corporation, and the percentage of export price received by the fishermen did not increase. The available data fail to suggest why these benefits were not forthcoming[1].

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[1]For further information concerning the impact of the Freshwater Fish Marketing Corporation on the marketing system and particularly its benefits to fishermen, see: Lamb, Charles W., Jr. and D. F. Mulvihill, "The Freshwater Fish Marketing Corporation of Canada," Institute for 21st Century Business, Kent State University, Kent, Ohio, 1974; and Lamb, Charles W., Jr., "A Comparative Analysis of Marketing Systems for Canadian Freshwater Fish," in "National Needs & Ocean Solutions: Proceedings of the Tenth Annual Conference," Marine Technology Society, Washington, D.C., 1974, pp. 1029-1038.

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Agricultural Extension, Marine Advisory Services Agree on Closer Cooperation

Close working relationships between State Cooperative Extension Services and marine advisory programs will be provided under a landmark interagency agreement signed 14 November 1974.

Under the agreement, the Extension Service of the U.S. Department of Agriculture representing State Cooperative Extension Services and the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce will work together to provide extension-type services to the marine community.

"The purpose of this agreement is to speed the cooperative efforts to get the results of scientific and technical advances directly to the user," said Robert M. White, NOAA Administrator. "We are delighted that the Extension Service, with its long history of successful activity of this nature, will work closely with NOAA's Marine Advisory Service as a result of this agreement."

By the terms of the agreement, NOAA will prepare a plan for developing marine extension and advisory programs in coastal and other interested states, and advise Extension Services of programs that might pertain to cooperative extension. Upon concurrence by Extension Service, the two services will coordinate the design of educational programs for disseminating information generated by NOAA and will develop and support educational programs on national, regional, state, and local levels.

NOAA's Marine Advisory Service will also cooperate with Extension Service in preparing educational materials and will provide funding where appropriate.

In addition, Extension Service will coordinate with NOAA in developing and conducting training programs through State Cooperative Extension Services, provide information to NOAA on marine resources and environmental problems concerning agricultural and rural communities, and assist in negotiating contracts and agreements between the State Cooperative Extension Services and NOAA.

The USDA's Extension Service is responsible for disseminating to the people of the United States information on subjects relating to agriculture and home economics. NOAA's National Sea Grant Program is responsible for furthering the development, conservation and wise use of America's marine resources, and for maintaining advisory services to achieve this purpose. Institutional recipients of Sea Grants are required to conduct advisory services, and in addition numerous Sea Grant advisory service projects are separately funded.

NOAA's Marine Advisory Service is under the direction of Howard Eckles, and operates under the aegis of the National Sea Grant Program. It involves advisory activities of other NOAA components, such as those of the National Marine Fisheries Service, as well as those of Sea Grant.

Man-Made Sea Slicks May Save Lives Says NOAA Scientist

A harmless man-made sea slick being studied as a hurricane suppressor may also help save lives another way, according to a scientist with the National Oceanic and Atmospheric Administration.

Duncan Ross of NOAA's Atlantic Oceanographic and Meteorological Laboratories in Miami, part of the Commerce Department agency's Environmental Research Laboratories, believes that a slick-forming chemical, added to the dye packets of life jackets and rafts would make it easier for rescuers to spot shipwreck victims or others cast adrift at sea.

Certain chemicals form temporary sea slicks on the surface of the ocean, covering the water with a thin, polymer membrane only a few molecules thick. A small amount of one such compound—polyvinyl alcohol, lineoleic acid and derivatives of polyvinyl acetate—can produce an acre of slick in 20 minutes, with a clearly visible, stable boundary. The chemicals used have been found to be of low toxicity, and the amounts involved are too small to harm aquatic life.

In 1973, two scientists with NOAA's National Hurricane Research Laboratory and the Illinois Institute of Technology announced that such a slick could block one of the channels feeding hurricanes. Hurricanes draw their destructive force from evaporation-produced heat energy from the ocean's surface. After experiments in the Gulf Stream east of Miami, the scientists concluded that the chemical film could effectively suppress evaporation and waves, and, therefore, inhibit the development of storms.

The man-made slicks, which produce a smoother-looking patch of water, even suppress the ripples on the bow wave of a ship. This wave-suppressing property, says Ross, makes polymer sea slicks potential lifesavers. Many lifejackets and rafts carry dye packets used in an emergency to create a splotch of bright orange in the water. The dye patch, however, is soon dissipated by waves.

The ability of sea slicks to calm the seas, Ross says, would assist in prolonging the life of the dye patch. Two ounces of oleal alcohol will form a slick about 200 feet (60 meters) in diameter that lasts several hours. Ross suggests adding the substance to life-jacket dye packets. The slick, he points out, is highly visible and can be detected by airborne radar, so an all-weather search could be conducted from high altitudes, greatly improving the efficiency of search and rescue operations.

MESA Program Office Set Up, Heads Named

A program to investigate how man has affected the marine environment has been established by the National Oceanic and Atmospheric Administration at its Environmental Research Laboratories in Boulder, Colo. Charles G. Gunnerson, a sanitary engineer specializing in pollution control in the oceans and estuaries, and in disposal, reclamation, and recycling of wastes, has been appointed director of the Commerce Department agency's Marine Ecosystems Analysis (MESA) program, and Edward G. Altouney, a civil engineer-economist experienced in public works and water resources, was named deputy program director.

MESA focuses on selected coastal and offshore regions to determine what can be done to correct past mistakes that have harmed the environment, and to learn how to predict the environmental consequences of future actions. The first major project is the New York Bight study which will define the impact of a dense human population on the environment. Another MESA study will assess the probable environmental impact of oil leasing in the Gulf of Alaska.

Prior to Gunnerson's appointment as MESA program director, he was director of the Great Lakes Regional Office of the International Joint Commission, a U.S.-Canada body established by treaty in 1909 to govern the use of the Great Lakes and other boundary waters. Before setting up the Commission's Great Lakes office, he had established a San Diego office of Woodward-Envicon Environmental Consultants where he planned and managed environmental impact, research, and management studies for industrial clients and government agencies. He has also served as manager of the Sanitary Engineering Laboratory of the Stanford Research Institute, directing research and development in water supply and pollution control, solid-waste management, and resources recovery. Gunnerson has also worked with the water quality section of the U.S. Public Health Service's Division of Water Supply and Pollution Control, and with the California Department of Water Resources.

A native of Storm Lake, Iowa, Gunnerson studied mining engineering at Iowa State University and civil engineering at Oregon State University. In 1947 he earned a degree in geology from the University of California at Los Angeles and later did graduate work in oceanography and marine bacteriology at the University of Southern California.

Before joining NOAA, Altouney was Senior Specialist in Engineering and Public Works for the Congressional Research Service of the Library of Congress. Previously, Altouney was staff assistant to the Assistant Secretary of the Interior for Water and Power Resources, where he supervised extensive investigations on water development programs and coordinated activities with other federal agencies and with state commissions. He also developed and conducted a water resources research and training program, involving major universities and private research groups throughout the country.

Altouney was on the staff of Stanford Research Institute coordinating institute-wide water research efforts and directing the development of research contracts in water resources. Like Gunnerson, Altouney has also worked—from 1958 to 1964—in the State of California's Department of Water Resources. Born in New York City, Altouney earned a bachelor's degree in civil engineering from Ecole Superieure d'Ingenieurs of the University of Lyons, France, and an M.S. from the Faculte des Sciences de Lyons in 1955; and, in 1963, a Ph.D from Stanford University in Engineering-Economic Planning.

NOAA Restricts Financial Assistance to Salmon Vessels in Alaskan Waters

The National Oceanic and Atmospheric Administration will not provide financial assistance that would significantly increase the harvesting capacity of vessels in the Alaska salmon fishery until further notice.

The Commerce Department agency has declared the Alaskan salmon fishery a "conditional fishery," which is defined in Commerce Department regulations as a fishery where there are already more than enough vessels to harvest the available catch.

Robert W. Schoning, director of NOAA's National Marine Fisheries Service which administers the financial assistance programs, said that the present harvesting capacity was already so great that the use of the Service's financial assistance programs would be inconsistent with the wise use, management, conservation, and protection of the fishery. Representatives of both Alaska State Department of Fish and Game and the Alaska Limited Entry Commission agree with Schoning's view.

The restriction on financial assistance is automatic upon such a declaration. The restrictions differ for each financial assistance program and are defined in the Commerce Department regulations covering the individual program. The two financial assistance programs affected are the Fishing Vessel Obligation Guarantee Program and the Fishing Vessel Capital Construction Fund Program.

The first program provides a Federal guarantee for obligations, financing, or refinancing (for up to 15 years) 75 percent of the cost of constructing, reconstructing, or reconditioning U.S. commercial fishing vessels of at least five net tons.

The second program is one under which Federal income taxes on fishing vessel income may be deferred in connection with constructing, reconstructing, or under certain conditions, acquiring U.S. commercial fishing vessels of at least five net tons. The programs will still be available to vessel owners already operating in the conditional fishery for approved purposes other than adding vessel capacity. The official announcement of the new policy was published in the Federal Register 23 September 1974.

Coast Guard Commissions LORAN-C Test Facility

The Coast Guard formally commissioned a LORAN-C test facility at Caribou, Maine on 22 November 1974. The Caribou facility was established to test new equipment and techniques to improve the world-wide LORAN-C Radionavigation System.

Transmitting equipment, LORAN-C monitoring equipment, communications equipment, a new LORAN-C transmitting antenna, and prototypes of all other new equipment necessary to operate the LORAN-C system are scheduled for installation at Caribou by mid-1976.

Fifteen Coast Guard military personnel, commanded by LCDR Stephen P. Plusch, operate the facility which will ultimately become a fully-operational LORAN-C transmitting station, paired with other East Coast stations to provide improved navigational services to mariners in the Gulf of Maine and neighboring areas.

Earlier last year, the Coast Guard announced plans to replace its Long Range Aid to Navigation (LORAN)

system known as LORAN-A, with the more modern LORAN-C over a five year time period. LORAN-C's primary advantages over LORAN-A are its accuracy and range. LORAN-C can provide more accurate position fixes over much wider areas for fishermen, offshore oilmen, and merchant mariners.

While LORAN-A can be used to identify a position that is accurate to from one to five nautical miles, LORAN-C can identify a position with one-quarter nautical mile accuracy or better, throughout the service area. In addition, LORAN-C signals are usable out to 1,200 to 1,500 miles from the transmitting stations, versus LORAN-A's 700- to 900-mile range. With LORAN-C's wider range, 15 "C" stations can do the work of 30 "A" stations.

Progress Seen In Lobster Culture

That cantankerous delicacy, the American lobster, is on his way to being "domesticated" for aquaculture purposes by a Sea Grant research team at the University of California's Bodega Marine Laboratory.

The interdisciplinary group headed by Robert A. Shleser is working to develop a commercially feasible system to farm lobsters and other marine animals. Within recent months they have reported success in:

1) Obtaining 80 percent survival of lobsters through the larval period;
2) Reducing cannibalism, a recurring and significant problem in lobster culture;
3) Developing a more cost-effective feed; and
4) Achieving successful matings, egg extrusion, and hatching on the west coast for the first time.

The project is sponsored by the National Oceanic and Atmospheric Administration through its National Sea Grant Program. The Commerce Department agency has mounted a substantial effort to develop commercially feasible aquaculture, both to add jobs to the economy and to provide additional sources of protein for the nation's food supply.

Using the sophisticated tools of genetics, biochemistry, and systems engineering, the Sea Grant team devised a larval rearing system that now achieves up to 80 percent survival of lobsters through the larval period (the first 30 days of life). Survival rates in the wild are unknown, but it is estimated that less than one-tenth of one percent of lobster larvae survive this critical first month.

The genetics laboratory, Bodega Bay, Calif., has identified a rare genetic trait that can be detected chemically with the tissue from one of the small legs of the lobster. The group is now engaged in producing a stock of these lobsters for release in areas where lobsters are heavily fished, to monitor the population for survival. The results will be used to evaluate the potential for restocking areas where natural populations have been depleted.

The goal of the California Sea Grant project is to develop the technology required so that lobsters can be grown to marketable size and harvested profitably. "To grow these animals successfully, we must control every aspect of their life cycle and environment—just as modern chicken growers control the lives of their broods," said Shleser. To accomplish this, he has put together a team of specialists in water quality, nutrition, engineering, physiology, genetics, and economics.

"Only with a group such as this," he said, "can we hope to understand and ultimately control every variable that goes into lobster farming. Then we can develop the specifications and cost estimates for a lobster farm to be located at a specific place, and tell whether or not it is likely to pay off."

The Sea Grant team reduced cannibalism in tank-grown young lobsters, without separating each animal, by increasing their food ration and providing a constant algae bloom in the water. They successfully held 44 lobsters in a 28- × 41-inch tank for three months with an 87 percent survival, compared to less than 60 percent survival during a similar period in a much larger and more complex environment. The constant presence of brine shrimp provided food, and the algae—more than a million cells per cubic centimeter—may have provided the density that kept the lobsters from seeing each other, or possibly they absorbed odors that may play a role in cannibalism. For larger animals, however, some form of physical separation still appears to be necessary.

A four-month experiment using artificial diets developed for the project showed that growth rates approximated those of lobsters fed on brine shrimp, with nearly 100 percent survival. Brine shrimp constitute the major food source for laboratory and experimental lobster research, but are too expensive for consideration in a commercial aquaculture operation.

The team has also achieved successful mating of lobsters, native to the east coast, in controlled conditions on the west coast. Several dozen lobsters have been bred, and four females have extruded eggs. Normally a 9- to 13-month interval between mating and extrusion is required, but in one instance the time was only three months. These animals are the first to perform the complete reproductive process on the west coast, and the work provides the basis for mating and selective breeding of stocks with economically important traits.

Manipulation of egg development by temperature control has been routinely achieved, based on successful work first carried out by the Massachusetts State hatchery on Martha's Vineyard. The Sea Grant group controls and predicts hatching. By planning in advance, it is possible to hatch lobsters at any time of the year. Lobsters have been hatched in most months since 1972.

Working cooperatively with this project has been another group, at San Diego State University, headed by Richard F. Ford. Ford and his associate, Jon Van Olst, are investigating the use of power plant thermal effluent as a means of reducing cost of heat for culture of lobsters and other species. This work is also part of NOAA's Sea Grant aquaculture effort. In addition, work by state fish hatcheries in Maine and Massachusetts, and by NOAA's National Marine Fisheries Service, has been drawn on by Shleser's team.

Marine Environment Curriculum Is Tested

Back in school last fall after a summer of swimming, sailing, surfing, or fishing, many a young Delaware stu-

dent began learning more about the marine environment than ever before. The reason: a Sea Grant education project of the University of Delaware became available for the first time.

Thirty Delaware schools received the university's brand new marine environment curriculum collection, and Sea Grant projects in nine other states—Rhode Island, Maine, New York, North Carolina, Maryland, Georgia, Mississippi, Alabama, and Hawaii—also purchased them. Each set consists of a collection of 65 "learning experience" folders, or packets of teaching materials. Each folder deals with a specific topic for teaching, along with reference materials. Where appropriate, such aids as discussion outlines, laboratory experiments, suggested field trips, tests, and visual aids are included.

Sponsored by the National Oceanic and Atmospheric Administration, the Marine Environment Curriculum Study is designed to relate specific problems of the marine environment to general fields of knowledge and study, in accord with the responsibility of the Commerce Department agency's National Sea Grant Program to encourage education and training related to wise use and development of marine resources.

"We have designed these lessons to be infused into a wide variety of courses," explained Robert W. Stegner, Professor of Biology and Education and director of the study. "Although a particularly marine-oriented school could use the Sea Grant collection as a nucleus for a unified course of study or for mini-courses, we think its major use will be to provide marine orientation—and awareness of the importance of our marine environment—in the standard curriculum."

Each of the 65 lesson packets is built around a single subject showing some aspect of ocean-atmosphere-land interaction. Concepts and lesson plans are keyed to subjects studied from kindergarten through twelfth grade, and encompass general science, biology, chemistry, earth science, mathematics, social studies, reading, art, language arts, and even home economics. The overall theme emphasizes that ocean-atmosphere-land relationships are critical and that improved knowledge of the marine environment is required for intelligent decision-making about environmental problems.

"One purpose of the study," says Stegner, "is to interweave throughout a student's school career an awareness of how important the oceans are to life, through lessons that supplement or reorient rather than displace ongoing courses of study."

The Sea Grant packets contain extensive visual material including slides and masters for making transparencies. Examples from the Delaware region are frequently used, but the lessons can be adapted to school systems throughout the United States.

Each lesson is related to one or more of four basic propositions—that an abundance of water makes the earth unique in the solar system; that the oceans interact with the earth and its atmosphere; that marine organisms interact in complex ecosystems; and that man is part of the marine ecosystem. Among the topics covered by individual lessons are:

1) Seaside Nature Trail—general science, grades kindergarten through 4;

2) The Not-so-common Oyster—general science, grades 3 through 5;

3) Useful Plants of the Sea—reading, grades 4 and 5;

4) The Sun, Moon, and Tides—earth science and mathematics, grades 6 through 12;

5) The subsets of Coastal Zone—mathematics, grades 7 through 9;

6) The Oil Spill Problem—earth science, grades 9 and 10;

7) Physical Properties of Water—biology and chemistry, grades 10 through 12;

8) Simulation Game: Superport!—social studies, grades 10 through 12.

A wide variety of readily-available reference materials are listed in the lessons, ranging from *Scientific American* to Thor Heyerdahl's books and *NOAA* quarterly. A 24-page bibliography of popular books on marine-related topics was prepared by James Schweitzer and published at the outset of the project.

The Marine Environment Curriculum Study is part of a comprehensive Population-Environment Curriculum Study, initiated by Delaware in 1968. Basic guidelines for curriculum development are incorporated in a Conceptual Scheme for Marine Environment Studies—prepared by marine biologist Maura Geens and Stegner—which also serves as a means of evaluating a marine environment education program.

Most of the teaching resource packets in the collection were prepared by Delaware teachers working with the project staff. New subjects are being developed and produced, so that teachers interested in developing awareness of the marine environment will have a more varied collection of teaching materials from which to choose. Continuous growth of the collection is planned and a means of commercial distribution is being sought.

In addition to Sea Grant Program support, the project has been aided by the Office of Environmental Education of the Department of Health, Education, and Welfare; the Delaware Department of Public Instruction; and the College of Education at the University of Delaware.

Foreign Fishery Developments

Japan's 1972-73 Fishery Exports Detailed

Japanese exports of fishery products in 1973 totaled 173,493 million yen (US$636 million, based on exchange rate of 273:1) on a customs clearance basis. This is an increase of 20.7 percent (in terms of US dollars) over the 1972 exports[1] worth 162,178 million ($527 million at 308:1). Canned mackerel, valued at $96 million, was the most important product, comprising 15.1 percent of the total value of fishery exports, followed by canned tuna, $89.5 million (14.1 percent); and frozen tuna, $78.9 million (12.4 percent).

The United States continued to be the chief market for Japanese fishery products. Exports to the United States totaled $226 million (35.5 percent), followed by Great Britain, $39 million (6.1 percent), and by West Germany,

[1]See also, "Japan Tells 1972-73 Fishery Product Trade," Foreign Fishery Developments, *Marine Fisheries Review*, 37:1, p. 55.

Japanese fishery exports, 1972 and 1973.

Fishery Product	1973 Quantity Metric Ton	1973 Value Y1,000	1973 Value $1,000[1]	1972 Quantity Metric Ton	1972 Value Y1,000	1972 Value $1,000[2]
Fresh, frozen						
Tuna						
Skipjack	102,686	13,478,991	49,374	52,281	6,914,997	22,451
Albacore	20,884	5,973,026	21,879	30,596	8,139,396	26,427
Yellowfin	13,885	1,904,833	6,977	15,095	2,479,420	8,050
Bluefin	0.3	1,880	7	25	5,690	18
Other tuna	1,051	181,167	664	1,310	200,466	651
Total tuna	138,506	21,539,897	78,901	99,307	17,739,969	57,597
Saury	23,066	3,367,899	12,337	21,481	3,722,770	12,087
Rainbow trout	2,315	1,099,584	4,028	2,519	904,047	2,935
Shark	2,122	577,491	2,115	4,715	1,558,848	5,061
Shrimp	4,086	3,504,047	12,835	3,939	3,755,906	12,195
Squid	25,707	4,765,508	17,456	25,729	3,999,613	12,986
Others	138,560	53,005,784	194,161	206,050	40,439,703	131,298
Total, fresh and frozen	334,362	66,320,313	242,932	264,433	54,380,988	176,562
Canned						
Tuna in oil						
Albacore	9,588	6,052,464	22,170	6,860	3,591,272	11,660
Skipjack	12,319	6,154,669	22,545	8,390	3,566,755	11,580
Other tuna	2,365	1,094,264	4,008	3,630	1,440,293	4,676
Total	24,272	13,301,397	48,723	18,880	8,598,320	27,916
Tuna in brine						
Albacore	9,160	5,879,599	21,537	20,609	13,195,777	42,844
Skipjack	6,143	2,787,436	10,210	4,882	2,372,906	7,704
Other tuna	68	30,598	112	465	178,710	580
Total	15,371	8,697,633	31,859	25,956	15,747,393	51,128
Tuna Specialty Packs						
Albacore	184	99,212	363	78	38,708	126
Skipjack	6,118	2,257,408	8,269	7,593	2,589,651	8,408
Other tuna	190	84,233	309	303	117,314	381
Total	6,492	2,440,853	8,941	7,974	2,745,673	8,915
Total, canned tuna	46,135	24,439,883	89,523	52,810	27,091,386	87,959
Salmon	13,446	10,418,665	38,164	30,350	17,196,075	55,831
Pacific mackerel						
Natural	79,369	11,071,532	40,555	81,570	8,805,832	28,590
Tomato Sauce	88,892	12,730,524	46,632	89,562	11,424,725	37,093
In oil	9,202	2,343,088	8,573	10,276	2,447,688	7,947
Other packs	499	107,758	395	3,045	596,009	1,935
Total, mackerel	177,962	26,252,902	96,165	184,453	23,274,254	75,565
Other fish	17,997	6,105,416	22,364	15,874	7,948,280	25,807
Total, canned products	255,540	67,216,861	246,216	283,487	75,509,995	245,162
Other products						
Whale Oil	20,626	1,692,707	6,200	31,646	1,554,992	5,049
Pearls	48	17,866,834	65,446	68	14,188,968	46,068
Pet Food	6,941	1,009,355	3,697	9,180	1,381,646	4,486
Fish meal	17,754	2,312,727	8,472	28,561	1,987,112	6,452
Other products	52,111	17,074,794	62,545	49,691	13,174,878	42,775
Total	97,480	39,956,417	146,360	119,146	32,287,596	104,830
Grand total	687,382	173,493,591	635,508	667,066	162,178,579	526,554

[1]273 Yen = US$1
[2]308 Yen = US$1

$32 million (5.1 percent). Principal products exported to the United States (excluding Puerto Rico) were frozen tuna ($54 million), canned tuna ($31 million), and canned mackerel ($11 million). In quantity, the 1973 fishery exports recorded 687,382 metric tons, up 3 percent compared with 667,066 metric tons in 1972.

Sources: *Suisan Shuho* and "Japanese Fisheries Trade in 1973 and Outlook" prepared by U.S. Embassy, Tokyo.

Republic of China, Saudi Arabia Okay Fishing Pact

The Republic of China (Taiwan) and the Kingdom of Saudi Arabia have entered into an agreement for fishing cooperation. Pursuant to that agreement, the Yung Hsin Fishing Company at Kaohsiung sent two 180-gross-ton fishing vessels to operate in the Red sea according to a 30 August 1974 report. The Kaohsiung Fishing Company reportedly will pay Saudi Arabia NT$3.2 million (approximately US$84,200) for fishing operations over a 20-month period. The Saudi Arabian government will send fishermen aboard the two vessels to receive training. The fish catch will be sold to the local markets.

Source: *China Post.*

Canadian Government Buys Canned Perch

A $1.5 million purchase program of canned ocean perch under the provisions of the Fisheries Prices Support Act was announced last fall by Canadian Fisheries Minister Roméo LeBlanc. The product, to be canned from stored stocks of Canadian ocean perch, will be used to meet the requirements of relief and development programs administered by the Canadian International Development Agnecy and the World Food Program.

All five Atlantic provinces are significant producers of ocean perch. Landings in 1973 exceeded 350 million pounds. The 1974 catch was significantly reduced partially because of the existing marketing situation. The purchase program will reportedly help reduce large inventories of ocean perch accumulated as a result of heavy landings in late 1973, coupled with a general decline in world demand for fishery products. The program is being administered by the Fisheries Prices Support Board which set a price of $1,200 per metric ton for the canned fish.

Japan and Colombia Set Skipjack Venture

The Japanese trading firm Kanematsu Kosho and Colombian interests have formed a joint skipjack tuna fishing venture in Cali, Colombia. The joint company, named International Maritimo Pesquera, was organized with a capital of 1 million pesos (approximately US$39,000), invested 40 percent by the Japanese and 60 percent by the local partners. This is the first instance of Japanese participation in a joint fishing venture in Colombia.

One baitboat sent from Japan, to provide technical training, and four other vessels (three Ecuadorian and one Colombian) will conduct fishing for the company out of Buenaventura. The planned catch during the first year is 3,000 tons of skipjack worth about $1.5 million. The new company plans to build in Buenaventura a 1,000-ton capacity cold storage plant, which reportedly will be the largest cold storage in Colombia.

Source: *Suisan Keizai Shimbun.*

JAPAN IMPORTS LESS SALMON

Japanese salmon imports were sharply down last year owing to poor harvest in the United States and Canada, the two major suppliers, and the depressed market in Japan. In recent years, between 5,000 and 8,000 tons of salmon were imported annually, and in 1973 the purchases jumped to 15,000 tons. Sharp gains in 1973 were attributed to increased consumption in Japan of salmon and other North Pacific species which gained popularity as "clean" fish amidst the uproar over local fish contamination by PCB, mercury and other pollutants, and to heavy buying by trading firms speculating on sharp price increases for salmon.

However, in 1974, the Japanese salmon market weakened, adversely affected by the tight money situation and consumer resistance to high-value seafood. This situation, coupled with high prices in the salmon producing countries because of poor fishing, discouraged the trading firms from importing the product which they could not sell at above cost. Total Japanese salmon imports in 1974 to 30 September 1974 were 2,990 metric tons.

Source: *Suisan Keizai Shimbun.*

Publications

Recent NMFS Scientific Publications

NOAA Technical Report NMFS SSRF-677. Gilmore, Gil, and Lee Trent. **"Abundance of benthic macroinvertebrates in natural and altered estuarine areas."** April 1974. 13 p.

ABSTRACT

The abundance of benthic macroinvertebrates during March-October 1969 in West Bay, Tex., was compared between 1) a natural marsh area, 2) an adjacent marsh area altered by channelization, bulkheading, and filling, and 3) an open bay area. Animals representing four phyla were caught. Abundance indices (areas combined) of the four groups in terms of numbers were 66.4 percent polychaetes, 29.6 percent crustaceans, 2.5 percent pelecypods, and 1.5 percent nemerteans; volumes were 44.0 percent polychaetes, 40.8 percent pelecypods, 10.7 percent nemerteans, and 4.4 percent crustaceans.

When all organisms were combined, they were slightly more abundant numerically and over twice as abundant volumetrically in the marsh than in the canals and were least abundant in the bay. Polychaetes were most abundant in the canals and least abundant in the bay; abundance was highest at stations with low to intermediate amounts of silt and clay or where vegetative matter was composed mostly of live sea grasses or detritus. Crustaceans were more abundant in the natural marsh than in the other two areas and showed a definite preference for sandy substrate in marsh areas. Pelecypods were numerically most abundant in the bay but volumetrically the marsh had the highest standing crop. Nemerteans were most abundant in the marsh and least abundant in the bay.

In general, the seasonal abundance of polychaetes and nemerteans varied little during the study, whereas crustaceans and pelecypods were abundant only during the spring and early summer. An exception to this seasonal abundance pattern was the reduction in numbers of polychaetes at the uppermost canal station where the habitat was apparently unsuitable due to low oxygen levels during the summer and early fall.

NOAA Technical Report NMFS SSRF-678. Ellis, Robert J. **"Distribution, abundance, and growth of juvenile sockeye salmon,** *Oncorhynchus nerka,* **and associated species in the Naknek River system, 1961-64."** September 1974. 53 p.

ABSTRACT

The Naknek River system contains eight interconnected and generally biologically discrete basins, each with a different ratio of spawning grounds to rearing area for sockeye salmon, *Oncorhynchus nerka,* and different densities of juvenile sockeye salmon and associated species of fish. Juvenile sockeye salmon and other pelagic species were sampled with tow nets at night. Sockeye salmon were the most common and abundant species in all basins, followed by threespine sticklebacks, ninespine sticklebacks, and pond smelt. Eighteen other species of potential competitor or predator fish were present.

In the summers of 1961 to 1963, juvenile sockeye salmon in the pelagic areas had a characteristic pattern of abundance for the entire system: abundance (catch per tow) of age 0 increased from early summer to midsummer and then declined to late August. The abundance in late August varied about threefold and, in general, was independent of variations in the number of parents from 1960 to 1963.

In July the abundance of age 0 fish in each basin was proportional to the amount of known contiguous spawning ground, but by late August this relation no longer existed. This change was at least partly due to migration of the age 0 fish—generally from basins of greater abundance of fish to those of lesser abundance. The larger and faster growing fish were the first to migrate. Not all basins were involved in these migrations.

The production of sockeye salmon smolts in the Naknek system is relatively stable. At least three major factors probably contribute to this stability: (1) the presence of several major spawning units or races in widely separated spawning grounds of different types, (2) the presence of several connected lakes, and (3) the migratory behavior of juvenile sockeye salmon during the first summer.

A mechanism which prevents the population of juvenile sockeye salmon from exceeding some upper limit is not apparent in the Naknek system. A reduction in growth in areas of high density was not apparent in the Naknek system in 1961-64 and apparently did not occur in 1957-65. Many kinds of predators on juvenile salmon are present but probably are not limiting production of smolts.

The data on abundance and growth of juvenile sockeye salmon and the distribution of the escapement and spawning grounds indicate that it should be possible to increase the production of sockeye salmon in the Naknek system. Two of the major basins, North Arm and Brooks Lake, which constitute about 35 percent of the system, are now

producing juveniles at very low levels. North Arm appears to suffer from too little spawning area, whereas Brooks Lake appears to have adequate spawning area but too few spawners.

Three factors in the biology of juvenile sockeye salmon of the Naknek system are of special significance to the managers of the resource and should be investigated in any effort to enhance the production of sockeye salmon in the Naknek system: (1) the abundance of smolts each spring is fairly constant for the system as a whole and not closely related to the abundance of the parents or, from 1961-64, even to the original abundance of age 0 fish; (2) the apparent growth of juvenile sockeye salmon and potential competitor species is not related to the abundance of these fish in any lake of the Naknek system; and (3) two major lakes, constituting about 35 percent of the rearing waters, do not receive age 0 sockeye salmon from other basins and are supporting relatively few sockeye salmon.

The question of what escapement of adult sockeye salmon is needed to ensure full production of juveniles is considered. The present study indicates that escapements in the range of 600,000 to 1,000,000 fish, as recommended by other studies, would probably fully use the present combination of spawning and rearing areas without danger of overburdening the food supply.

NOAA Technical Report NMFS CIRC-389. Williams, Austin B. **"Marine flora and fauna of the northeastern United States. Crustacea: Decapoda."** April 1974. 50 p.

ABSTRACT

The manual includes an introduction to general classification, an illustrated key, an annotated systematic list, a selected bibliography, and a systematic index to the marine decapod crustaceans of the inshore and continental shelf waters of the northeastern United States.

NOAA Technical Report NMFS CIRC-390. Engett, Mary Ellen, and Lee C. Thorson. **"Fishery publications, calendar year 1973: Lists and indexes."** September 1974. 14 p.

ABSTRACT

The following series of fishery publications of the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, in calendar year 1973 are listed numerically (with abstracts) and indexed by author, subject, and geographic area: NOAA Technical Report NMFS CIRC (formerly Circular); Data Report; Fishery Facts; NOAA Technical Report NMFS SSRF; and NOAA Technical Memorandum NMFS.

NOAA Technical Report NMFS SSRF-675. Shomura, Richard S., and Francis Williams (editors). **"Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, 9-12 August 1972. Part 2. Review and contributed papers."** July 1974. 335 p.

(No abstract)

Data Report 85. Clark, Stephen H., Dennis A. Emiliani, and Richard A. Neal. **"Release and recovery data from brown and white shrimp mark-recapture studies in the northern Gulf of Mexico, May 1967-November 1969."** July 1974. 152 p. on 3 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

During seven mark-recapture studies conducted in the northern Gulf of Mexico during the period May 1967 to November 1969, personnel at the Galveston Laboratory released 75,947 brown shrimp *(Penaeus aztecus)* and 38,628 white shrimp *(P. setiferus)* marked with biological stains, fluorescent pigments, and plastic tags. Recovery of 6,192 brown shrimp and 917 white shrimp, provided data on growth, mortality, migration, and distribution by area and depth. Data for individual recoveries and other pertinent information are summarized in this report.

Data Report 86. Weber, Douglas D. **"Observations on growth of southeastern Bering Sea king crab,** *Paralithodes camtschatica,* **from a tag-recovery study, 1955-65."** August 1974. 122 p. on 2 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

Growth data from a 10-yr tag-recovery study of southeastern Bering Sea king crab, *Paralithodes camtschatica,* were evaluated for sources of error and the usable growth information documented.

For simplified analysis of growth data the adult male crab growth increments may be combined since the increase in carapace length per molt averages 17.5 mm irrespective of size. For female crabs the growth per molt decreases with increase in carapace length.

The crabs' migratory pattern, molting stage at time of tagging, area of recapture, and selectivity of the fishery can influence interpretation of the growth data. The interaction of these parameters are presented, and it is suggested that these factors be considered in data application.

Data Report 87. Collins, L. Alan, and John H. Finucane. **"Hydrographic observations in Tampa Bay and adjacent waters, May 1971 through April 1973."** August 1974. 146 p. on 3 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

Hydrographic data are given for water temperature, salinity, dissolved oxygen and turbidity. Additional data include chlorophyll *a, b,* and *c,* astacin and nonastacin carotenoids, and primary productivity based on chlorophyll *a* extraction for 29 stations in Tampa Bay and the adjacent coastal waters from Clearwater south to Sarasota, Fla. Data on air temperature, water temperature, salinity, and turbidity from daily observations at three sport fishing piers are provided. Tables summarize mean, range, and number of observations for each of the parameters by the months in which sampling occurred.

Data Report 88. Petersen, Duane H. **"Trawl catches and oceanographic data from NMFS surveys of the Gulf of Alaska pandalid shrimp resource, 1970-72."** August 1974. 573 p. on 9 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

Trawl catch and oceanographic data collected from five National Marine Fisheries Service cruises to assess the relative abundance of the pandalid shrimp resource in the Gulf of Alaska during 1970-72 are presented.

Station data are arranged in tabular form and provide information on location, depth, time and distance trawled, type of fishing gear

used, and species catch by weight. Bottom temperatures and salinities for some studies are also included.

Data Report 89. Turner, William R., George N. Johnson, and Herbert R. Gordy. **"Compendium of juvenile menhaden surveys in coastal streams of the northern Gulf of Mexico."** August 1974. 189 p. on 3 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

Catches of juvenile Gulf menhaden with two-boat surface trawls in coastal streams along the northern Gulf of Mexico are compiled for the period from 1964 through 1969. The catches are presented chronologically with accompanying hydrological data (including Secchi disc measurements, salinity determinations, and surface water temperatures) collected at each sampling station. Maps are provided defining the various areal designations, streams, and sampling stations.

Data Report 90. Saloman, Carl H., and L. Alan Collins. **"Hydrographic observations in Tampa Bay and adjacent waters—1972."** August 1974. 176 p. on 3 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

Hydrographic data include water temperature; salinity; total phosphorus; total Kjeldahl nitgrogen; pH; dissolved oxygen; turbidity; water transparency; chlorophyll *a*, *b*, and *c*, astacin and nonastacin carotenoids; and primary productivity based on chlorophyll *a* extraction. Methods of collecting and analyzing samples are described. Tables summarize data collected from 30 permanent stations by month and area. Additional tables summarize the mean, range, and number of observations of samples taken twice daily at the Laboratory dock.

Data Report 93. Trent, Lee, Edward J. Pullen, Genevieve Adams, and Gilbert Zamora, Jr. **"Catch per unit effort and mean total length of brown shrimp, *Penaeus aztecus* Ives, taken by trawl in the Galveston Bay system, Texas, 1963-67."** September 1974. 42 p. on 1 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

This report presents catches per unit effort and mean lengths for brown shrimp, *Penaeus aztecus* Ives, taken with a trawl and trawl cod end cover from the Galveston Bay system, Tex. during 1963-67 by personnel of the Estuarine Program, National Marine Fisheries Service, NOAA, Galveston, Tex. The number of stations at which samples were taken ranged from 58 in 1963 to 16 in 1967. Sampling frequency varied from weekly to monthly; in 1967 samples were not taken throughout the year. Stations were located within three habitats—peripheral, open water, and channel—within each bay area of the system except West Bay. Catch per unit effort was defined as the number of brown shrimp caught per 5-min tow in a 0.6× 3.0 m otter trawl and the number caught per tow in the cod end cover.

Data Report 94. Hall, John R., and William N. Lindall, Jr. **"Benthic macroinvertebrates and sediments from upland canals in Tampa Bay, Florida."** September 1974. 221 p. on 4 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

Samples from 34 stations in upland canals of Tampa Bay, Fla. contained 139 species and 66,326 specimens of benthic macroinvertebrates. Collections were made from August 1970 through November 1971. Tables give monthly counts by species, individuals, and total individuals per square meter. A summary of the total number of species and individuals, and their monthly range and mean is presented. Mean grain size, standard deviation, skewness, kurtosis, and weight percentage of granule, sand, silt, and clay-sized sediment particles are also recorded.

NOAA Technical Memorandum NMFS ABFL-3. Bailey, Jack E., and Sidney G. Taylor. **"Salmon fry production in a gravel incubator hatchery, Auke Creek, Alaska, 1971-72."** November 1974, iv + 13 p.

ABSTRACT

Survival and physical characteristics of pink salmon fry, *Onchorhynchus gorbuscha*, incubated in two types of boxes, each box containing about 1 m^3 of gravel, and a Heath incubator were compared with fry from natural spawning to evaluate the use of boxes to produce fry. The gravel incubators were seeded at densities of 74,200 to 198,000 eyed eggs/m^3. Survival from eyed eggs to emergent fry ranged from 79 to 97 percent in artificial incubation, but the number of incubators tested was too small to define any relationships between survival and incubator type or egg density. With artificial incubation in gravel, survival from potential eggs in females to emergent fry was 69 percent, whereas with natural spawning and incubation in the creek, survival was about 12 percent.

Fry emerged from gravel incubators about 3 days earlier than from the streambed. The gravel incubator fry were larger than tray fry but smaller than creek fry. The smaller size of the gravel incubator fry could not be explained entirely on the basis of early emergence.

Further studies were recommended to determine whether the muskeg sediment that accumulated in the incubators, the low oxygen level (57 to 69 percent saturation), or the substrate particle size and composition inhibited growth of the embryos.

Floating Breakwaters, Fisherman Ecology Are Subjects of Two New URI Volumes

The **Proceedings of the 1974 Conference on Floating Breakwaters** are available from the University of Rhode Island Sea Grant program. Papers printed in the 304-page proceedings cover the topics of theoretical treatment of the different modes of wave suppression, experiments performed on model and prototype breakwaters, descriptions and evaluations of commercially available floating breakwaters, materials for breakwater construction, and the economics of floating breakwaters.

The proceedings also contain a list of conference participants and a suggested list of nomenclature for use by researchers. Editor of the breakwater conference report is Tadeusz Kowalski, URI professor of ocean engineering. The Floating Breakwaters Conference was held last spring (1974) at Newport, R. I. The conference was co-sponsored by the University of Washington and URI.

Two centuries of history and a present day sociological study of the Rhode Island fishing community, Gali-

lee, are presented in a recently published book titled, **Fishermen of Galilee.** The book is the result of a study by two University of Rhode Island professors, John J. Poggie, Jr., an anthropologist, and Carl Gersuny, a sociologist. The 116-page illustrated book has been published by URI's Sea Grant program.

Beginning with the Indians and early settlers who fished the salt ponds and the shore with small nets, the authors recount the history of the community through its hardships until the present day prosperity with a small, highly mechanized fleet. The authors examine the present-day community in terms of human ecology which they believe is the most useful approach in understanding maritime occupational cultures.

Gersuny and Poggie tell how Galilee has coped with 20th century economic conditions with harbor improvements and a new fishermen's cooperative. Taboos, the URI social scientists write, have enabled the fishermen to contend with the danger and uncertainty of their occupation. Many of their observations are based upon interviews with fishermen and a number of textile factory workers.

By comparing fishermen with factory workers, the social scientists found out that the fishermen have an unusual basic love for their occupation. "It would appear," Gersuny and Poggie say, "that the fishermen consider success and advancement in their occupation to be the main source of reward in their life, whereas the sense of the mill workers' responses indicates that they would like to have enough money to be free of their occupation."

Independence, challenge, disdain for regimentation and love of the outdoors are valued highly by fishermen while factory workers concern themselves with the steadiness of their work, the regular hours and security, the authors state. "In a sense," they write, "fishing is indeed a modern version of the primordial life way of our species—the hunting and gathering way of life. Perhaps in many ways, man is structured to be a hunter more than he is to be part of bureaucratized life in urban industrial society."

Copies of "Fishermen of Galilee" are available at a cost of $3 each. Requests for publication P346 should be mailed to the Marine Advisory Service, University of Rhode Island, Narragansett Bay Campus, Narragansett, RI 02882. Copies of the Floating Breakwaters Conference, Proceedings, publication No. P347, are available for $5 each from the same source.

Bristol Bay Study Is Published

A new report published by the University of Alaska's Institute of Social, Economic and Government Research (ISEGR)—**Bristol Bay, A Socioeconomic Study**—surveys the socioeconomic characteristics of that Alaska region. Compiled and written by economist David T. Kresge and research assistants Susan R. Fison and Anthony F. Gasbarro, the report was originally prepared under contract to the U.S. Army Corps of Engineers as part of a larger report, "The Bristol Bay Environment, A Background Study of Available Knowledge."

The original study was intended to provide background information for possible inclusion in environmental impact statements relating to petroleum development in Bristol Bay. The new ISEGR report explores seven major categories of socioeconomic importance: population and education; labor force and employment; income and cost of living; housing and public services; industrial activity; transportation facilities and costs; and land use and land status.

ISEGR has published the report as part of its Man in the Arctic Program, a long-range research effort intended to develop a basic understanding of the forces of change in Alaska and to apply this understanding in dealing with the critical problems of social and economic development. ISEGR has chosen Bristol Bay as a region in which further intensive research will be carried out under the Man in the Arctic Program. Its new report, as a compilation of available current information and historical data, will serve as a baseline for further studies in which socioeconomic data not presently available will be compiled and analyzed. Copies of the report can be obtained from ISEGR at $5 each.

New Aquaculture Magazine Debuts

Four fish farming magazines were combined last fall into one new, bimonthly publication, *The Commercial Fish Farmer and Aquaculture News.* The first issue (September-October 1974) was published last fall and distributed to the combined circulation lists—more than 14,000 persons—of the predecessor publications.

The new magazine, largest of its kind in the world and devoted exclusively to fish farming and aquaculture, is a consolidation of *The Catfish Farmer, Fish Farming Industries, American Fishes and U.S. Trout News,* and *The American Fish Farmer and World Aquaculture News. The Catfish Farmer* was the official publication of the Catfish Farmers of America, the Little Rock, Arkansas-headquartered national trade association of the catfish farming industry. *American Fishes and U.S. Trout News* was the official publication of the U.S. Trout Farmers Association which was headquartered in Washington, D.C. until last fall. *Fish Farming Industries* and *The American Fish Farmer and World Aquaculture News* were independent publications. The new magazine will be the official publication of the Catfish Farmers of America.

Publisher and general manager of the new publication is Porter Briggs and the editor is Maurice Moore. Publication offices are at 530 Tower Building, Little Rock, AR 72201.

U.N. Water Resources Materials Are Listed

A checklist describing some 200 United Nations System publications on water is now available from Unipub, U.S. distributor for publications of the United Nations System, and related publishing programs. Subjects covered in the checklist include irrigation, desalination, climatology, water pollution, environmental protection, waste disposal, nuclear applications in agriculture, and hydrology. The information is presented in books, maps, and microform.

Copies of the water resources checklist are available free of charge from: Unipub, Box 433, Murray Hill Station, New York, NY 10016.

In Brief . . . .

Awards, Salmon, and Sea Turtles

. . . . **Texas' first successful redfish spawns were almost completely wiped out** when a power failure cut oxygen circulation in holding tanks at the Palacios Marine Fisheries Research Station according to the Parks and Wildlife Department. Of the 43,000 redfish hatched in late September 1974, perhaps 1,500 survived. About 99 percent of the first spawn were lost and 90 percent of the subsequent spawn died. . . .

. . . . University of Rhode Island oceanographer **John A. Knauss has received the National Sea Grant Award,** an engraved silver tray and a $500 honorarium, for his contributions to the understanding and utilization of ocean resources. Provost for marine affairs at URI, Knauss has worked on national ocean policy and international sea law. . . .

. . . . The fall 1974 salmon run in New York's Great Lakes tributaries has been described as **"the biggest since the first Pacific salmon were stocked in 1968"** by the Department of Environmental Conservation. Adult chinooks and cohos averaged several pounds heavier than the year before, a fact attributed to lamprey control. The run is also being termed a "small preview" of the developing Great Lakes salmonid fishery. Lamprey control and the salmon stocking program is credited with creating the new fishery for Lakes Erie and Ontario. The State plans a new hatchery to produce 3-4 million salmonids by 1978-79 and 5 million fish for stocking when at full capacity. . . .

. . . . **The Gold Medal Award of the International Oceanographic Foundation** for Outstanding Contributions to Oceanography has been presented to Edwin A. Link for his personal endeavors and support of the advancement of the scientific study of the oceans. Holding 27 patents, Link is known for such inventions as Link flight trainers and simulators, and navigation and marine diving equipment. . . .

. . . . **Physical oceanographer Warren S. Wooster,** Dean of the University of Miami's Rosenstiel School of Marine and Atmospheric Science has been elected vice president of the International Council for the Exploration of the Sea, the oldest intergovernmental organization concerned with marine sciences. A former member of the Scripps Institution of Oceanography faculty, Wooster is known internationally for his leadership in generating and assuring cooperation in oceanographic research among nations. . . .

. . . . **A 10-year program to create and enhance salmonid** runs in the Willamette River system is showing positive results, the Fish Commission of Oregon reports. Long-range adult chinook salmon escapement goals are on target and the upstream run has increased from 11,826 in 1972 to an all time record 33,924 for 1974. The Commission hopes to establish a self-sustaining wild population of the fall chinook in the upper Willamette. Full development of the system reportedly could produce an annual Pacific Coast sport and commercial harvest of 640,000 fall chinook. . . .

. . . . **While Galveston Bay, Tex. oyster populations are mending** after heavy 1973 flood damages, Texas Parks and Wildlife biologists are still not enthusiastic about the current season. Harvest increases are not expected until the 1975-76 season as flooding destroyed almost all oysters in Trinity Bay and did moderate damage to oysters in Galveston and East Bays. . . .

. . . . **A cooperative white shrimp tagging project,** "Operation Shrimp Survival," between the Texas Parks and Wildlife Department, the Texas A&M Extension Service, and the National Marine Fisheries Service is set to determine the species' growth rates, migrational patterns, abundance, and fishing and natural mortality rates. Some 20,000 white shrimp were tagged with small green discs and released last September in Galveston Bay. Capture data is being reported by sport, bait, and commercial shrimp fishermen to local shrimp houses and marinas. . . .

. . . . **Nearly 1,300 tagged yearling green turtles were released** on Florida beaches in the continuing Florida Department of Natural Resources Marine Research Laboratory restocking study, according to *Florida Conservation News*. The first survival studies of pen-reared sea turtles in their natural habitat were made in 1964 but the program to collect green turtle eggs from Florida beaches was not developed until 1971. . . .

. . . . **Texas' worst 1973 fish kill** saw some 3,800,000 marine fish perish from unknown causes in the Gulf of Mexico off Chambers, Galveston, Brazoria, and Matagorda Counties, the Texas Parks and Wildlife Department notes. In all, more than 6.3 million fish died in 84 kills during fiscal year 1973 in that state. . . .

. . . . **A pygmy sperm whale that washed ashore at Holmes Beach, Fla. late last summer died** within a week from dehydration caused by an ingested plastic bag, according to a *Florida Conservation News* report. An autopsy on the 570-pound animal found the lethal two square yards of heavy-duty plastic in her stomach that prevented natural absorption of fluids. . . .

. . . . **New York State's sea lamprey control program is going inland**—to Seneca and Cayuga Lakes where the parasite is causing 6-10 percent mortality among trout, according to the Department of Environmental Conservation. Control, rather than eradication, is intended, using the larvicide TFM, the same technique successfully used to kill young lampreys in Great Lakes tributary streams. A 90 percent reduction is expected. . . .

. . . . **To store, interpret, and transfer voluminous scientific information** on Chesapeake Bay and adjacent waters, the Virginia Institute of Marine Science, with RANN (Research Applied to National Needs, National Science Foundation) and Commonwealth of Virginia funds, has established a depository dubbed MERRMS (Marine Environment and Resources Research and Management System). It provides a multi-faceted information system designed to transfer interpreted scientific information from scientist to manager as well as between scientific disciplines. Modern data handling techniques using microfiche, random access slide displays, and computer indexing give rapid access to the data. . . .

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